Graz University of Technology

Diploma Thesis

Definition and Conception of a Continuous Improvement and Feedback Process at Leitner Shriram Manufacturing Ltd.

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Sterzing, 11.02.2011 Peter Rabanser

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ABSTRACT

Competitiveness on the global market is continuously increasing. Competition demands for high quality products in order to survive in the long run. This led to a constant development of quality management systems over the last decades. The perception of quality changed from the prior simple product quality that described its characteristics, to a modern quality, which comprises all company processes from the customer requirements to the satisfaction of their needs. A good quality management will help save costs and build the company on a solid base.

This thesis gives an overview on the basics of modern quality management approaches and the way it is lived in a South Indian windmill manufacturer.

Furthermore two processes, a continuous improvement process and a feedback process are analyzed in order to find improvements and increase their efficiency.

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1 Introduction

During my search for an interesting topic for my diploma thesis, I had the opportunity to get in touch with the LEITWIND Company. LEITWIND joined a joint venture with an Indian windmill manufacturer. This led to the opportunity for me to write on the Quality Management of this young corporation.

1.1 About the companies

LEITWIND is part of LEITNER TECHNOLOGIES group, a name which has been a synonym for high performance technology of ropeways and snow groomers since 1888.

LEITNER TECHNOLOGIES employs more than 2400 people worldwide at its plants in Italy, Austria, France, India and North America, as well as in 70 sales and service points. Since 2000, continuous research and development coupled with a high degree of technological competence have enabled LEITWIND to take advantage of synergies between the ropeway and the wind turbines technologies. The resulting turbine is an integration of a direct drive generator into a wind turbine. In 2003, Leitner produced and installed its first wind turbine prototypes that incorporated this revolutionary technology. Starting in 2007, LEITWIND began serial production of wind turbines. For the engineers, the search for quality and simplicity is a primary objective in all of the group's businesses. Because simplicity combined with quality guarantees highest reliability and profitability. Since the company's inception, LEITNER TECHNOLOGIES's success is based on quality and leading edge technology[1]

Leitner Shriram Manufacturing Limited (LSML) is an enterprise with a combination of engineering tradition of Shriram EPC and Leitner Technologies' spirit of innovation. Leitner Shriram Manufacturing Limited's strength is its knowledge capital, human capital and teamwork. The core strength of its team of over 200 members- emanates from its vast experience and thorough understanding of wind electric generator manufacture from ground zero level.[2]

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[1] LEITWIND: About us: Leitwind Homepage <http://en.leitwind.com/Company> accessed 11 January 2011

[2] LSML: About us: LSML <http://leitwind.in/aboutus.html> accessed 20 September 2010

1.2 World wind energy market

In 2009 the worldwide energy capacity reached 159.213 MW, out of which 38'312 MW were added in 2009. Wind power showed the highest growth rate since 2001, with 31,7%. The trend in wind energy shows that wind capacity doubles every 3 years (see Figure 1-1). Although the capacity is increasing rapidly, the generated power only equals 2% of global electricity consumption.

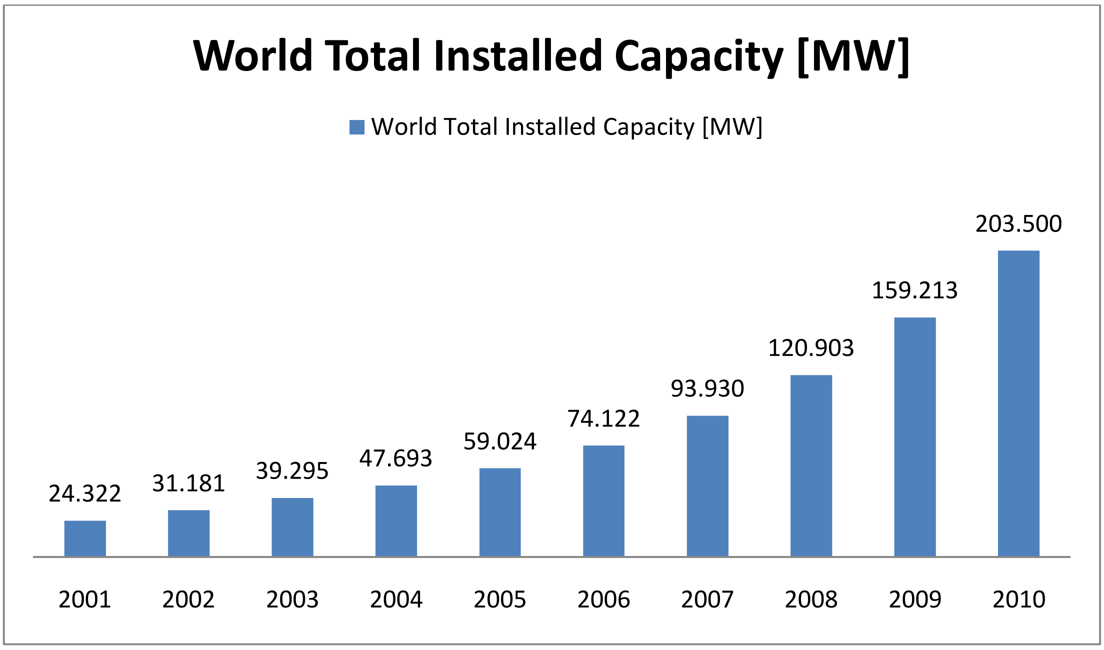

Figure 1-1: World total installed wind energy capacity[3]

Asia accounted for the largest share of new installations (40,4 %), followed by North America (28,4 %) and Europe fell back to the third place (27,3 %).[4]

Wind conditions in India are very good, especially in the southern part. They are influenced by the strong south-west summer monsoon, which starts in May-June, when cool, humid air moves towards the land and the weaker north-east winter monsoon, which starts in October, when cool, dry air moves towards the ocean. During the period March to August, the winds are

[3] WORLD-WIND-ENERGY-ASSOCIATION: World Wind Energy Report 2009 <http://www.wwindea.org/home/index.php?option=com_content&task=view&id=266&Itemid=43> accessed November 2010

[4] WORLD-WIND-ENERGY-ASSOCIATION: World Wind Energy Report 2009 <http://www.wwindea.org/home/index.php?option=com_content&task=view&id=266&Itemid=43> accessed November 2010

uniformly strong over the whole Indian peninsula, except the eastern peninsular coast. Wind speeds during the period November to march are relatively weak, though higher winds are available during a part of the period on the Tamil Nadu coastline. Tamil Nadu is the most interesting part in India for wind energy production, because of the fact that both monsoons bring wind over the southern part of the state.[5] Figure 1-2: wind map of India shows the wind rich areas (red) in India.

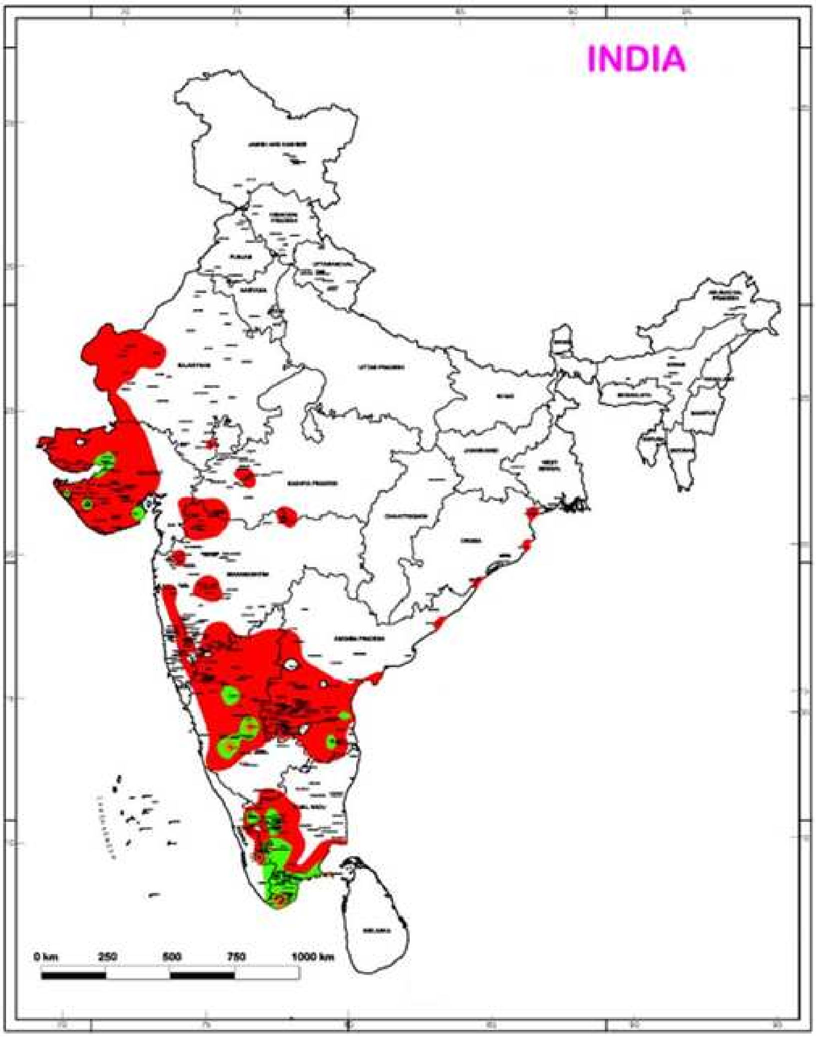

Figure 1-2: wind map of India [6]

[5] INDIAN-WIND-ENERGY-ASSOCIATION <http://www.inwea.org/imgs/wpd.jpg> accessed 20 Ocotber 2010

[6] INDIAN-WIND-ENERGY-ASSOCIATION <http://www.inwea.org/imgs/wpd.jpg> accessed 20 Ocotber 2010

Although India was a latecomer in the wind industry, domestic support followed by investments from big companies led India to become the country with the fifth largest installed wind power capacity in the world and the leader in the developing world. Table 1 shows the actual gross potential and the installed capacity of wind power in different states of India.

S. No.	State	Gross Potential (MW)	Installed Capacity (MW)
1	Andhra Pradesh	8.968	136
2	Gujarat	10.645	1864
3	Karnataka	11.531	1473
4	Kerala	1171	46,5
5	Madhya Pradesh	1.019	229
6	Maharashtra	4.584	2078
7	Orissa	1.700	2
8	Rajasthan	5.400	1088
9	Tamil Nadu	5.530	4907
10	West Bengal	450	1,1
	Total	**50.998**	**11824**

Table 1: Installed wind power capacity in India as of 31.October 2009[7]

The usage of power is increasing day by day and there is shortage of power to meet the current needs. This led to search of alternative energy in the form of renewable and non-conventional sources of energy. It is being estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012 forming 50% of all the non-conventional energy sources. Although, the installed capacity accounts for 6% of country's power, the generation is only close to 2% of country's power. This is mainly because of very less policy incentives for the operation of the wind farm.[8]

[7] WINDPOWER-INDIA: Indian Windpower <http://www.windpowerindia.com/statstate.html#map> accessed November 2010

[8] BUSINESS-STANDARD: India to add 6 GW wind power <http://www.business-standard.com/india/storypage.php?tp=on&autono=44562> accessed November 2010

1.3 Problem situation and objectives

The actual situation at LEITWIND is as follows. After starting with the research and development in the field of windmills in 2002, first prototypes were built and installed in South Tirol in 2003. 4 years later, a joint venture with an Indian windmill manufacturer was founded, the LSML. The LSML is responsible for the production of windmills in India. However the headquarter with the management, R&D and technical department remained in Italy. This led to a huge exchange of information between the two different continents. This is why a good communication between the technical department of LEITWIND in Italy and the LSML in India is vital for the success of this joint venture.

Because of the fast growth of this branch, and the big demand from the market, the processes have to adapt to the constantly changing needs. At the moment the standardization of the communication processes between the two locations, Italy and India requests high attention. This led to the objectives of the thesis. Figure 1-3 shows the connection between the main processes: Trouble Shooting, R&D and technical department situated in Italy, Manufacturing, Installation and Maintenance and Central Monitoring Station in India.

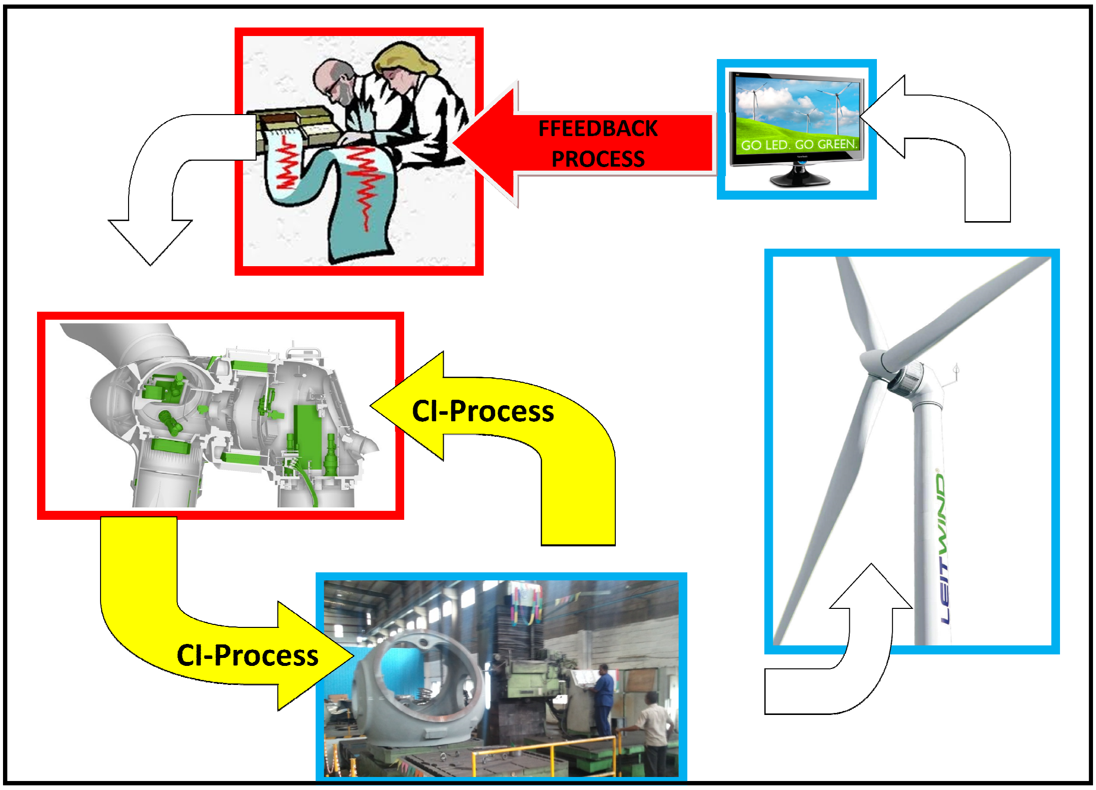

Figure 1-3: The Information Loop between Italy (red) and India (blue) (own illustration)

The main objective of this thesis is to improve the communication between different interfaces in the implemented quality management system at LSML. Good communication is especially required between the Central Monitoring Station (CMS) of India and the Trouble Shooting department in Italy and between the manufacturing department in India and the technical department of Italy.

The approach to the problem is structured in two steps. First of all an overview on the ongoing implemented processes has to be gained and two new processes, the Continuous Improvement Process and the Feedback Process have to be designed in order to build an information channel between the two different continents. This work should help to close the process circle of the LEITWIND Company and to ensure continuous improvement to the product.

2 Quality Management

Companies worldwide nowadays have to put peculiar attention on customer satisfaction. This is why modern quality management strategies base on the client's needs. Their products and services should not just meet the expected requirements but exceed the customer expectation. In order to do so, the evolution of quality management strategies changed drastically. Increased worldwide competitiveness nowadays demands methods that go far beyond usual quality standards and certifications.

To fully understand the real meaning of Quality Management (QM) this chapter will lead through the basics of QM and describe how modern QM approaches developed in the past.

2.1 Basics of Quality Management

The common understanding of modern QM still varies a lot between different authors. That's why Zollondz tries to build up a basic model from which all other models can be deduced. To describe better what a QM is, we have to know which elements are necessary. He describes seven elements, without them no QM can exist and calls this model the "Conditio-Sine-Qua-Non-QM-Model"[9] (see Figure 2-1).

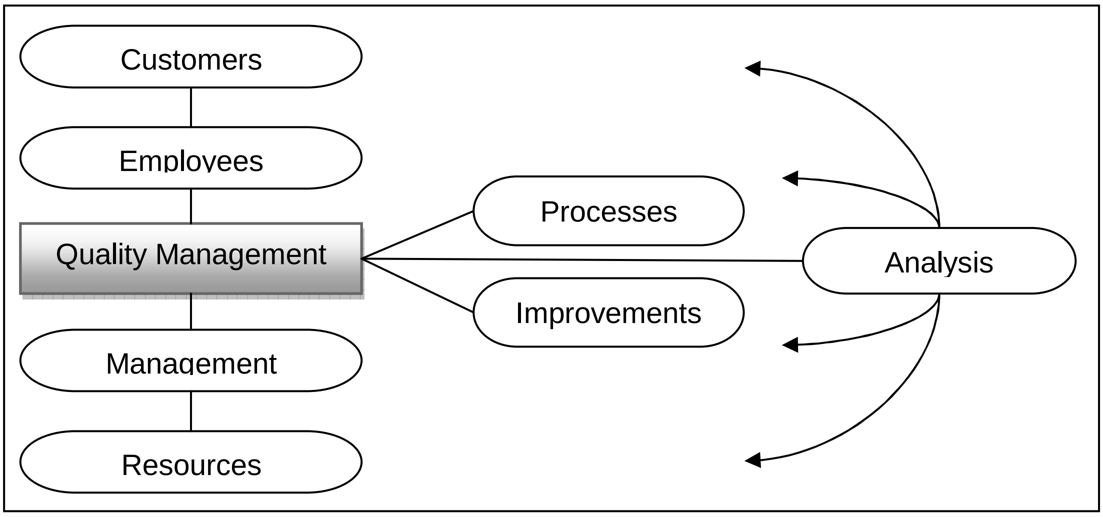

Figure 2-1: the 7 QM-Elements of the Conditio-Sine-Qua-Non-QM-Model according to Zollondz

[9] ZOLLONDZ, H.D.: Grundlagen Qualitätsmanagement, 2nd edn, München 2006.

The model contains seven elements that describe:

1. Customers: from the expectations of the customers the quality requirements have to be deduced.
2. Employees: the employees have to be trained in order to develop quality awareness. Quality management enhances dedication to the company by every employee.
3. Management: the management has to set up the quality policy and the resulting quality goals. The resources have to be provided. Not only the employees but also and especially the management has to be involved in Quality Management issues, they have to act as role model.
4. Resources: material and immaterial resources have to be supplied by the management.
5. Processes: main-, management- and support processes have to be identified and their quality capability has to be assessed.
6. Improvements: the continuous improvement process has to be implemented as an integral part of the quality management. The main goal is to reduce waste.
7. Analysis: without measurements and data analysis the QM has no footing and orientation. Data supplies the management with the information important to take the right decisions for the future. Not only the product has to be analyzed, but as well the processes and the customer satisfaction.

Based on these Elements many different Quality Management Systems (QMS) arose in the past. A QMS can be defined as a set of coordinated activities to direct and control an organization in order to continually improve the effectiveness and efficiency of its performance. The right implementation of a QMS enables an organization to achieve goals and objectives set out by the management in the company’s policy and strategy.

As shown in Figure 2-2, QMS can be seen as a wedge along the journey of quality that prevents good practices from slipping.[10]

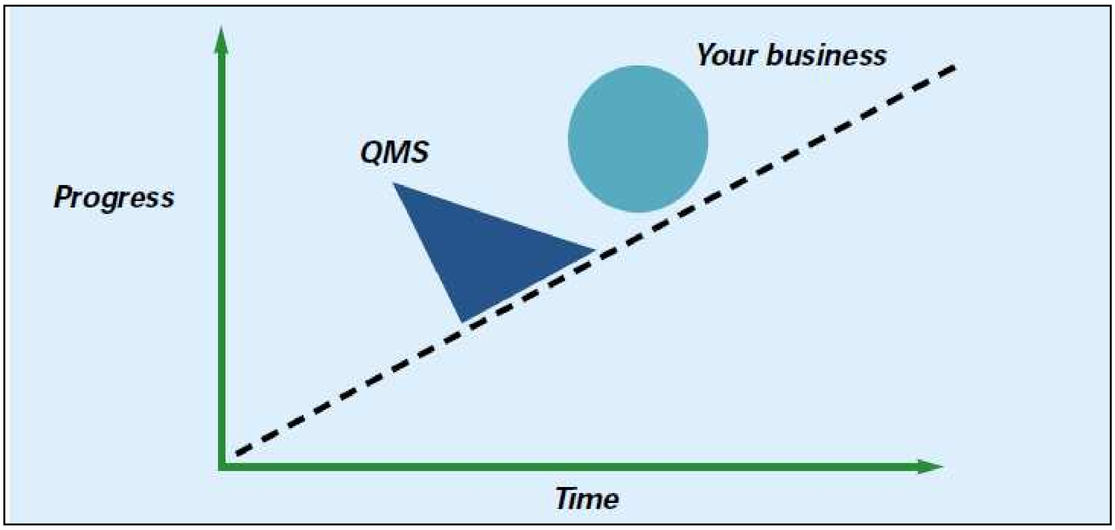

Figure 2-2: QMS serves as wedge along the journey of quality[11]

In the past the assumption that high quality can be achieved through extended quality checks ruled. However, nowadays this conception vanished in most of the branches. The new sight says that quality can only be created and not checked. It develops during planning and production and is visible at the end of the process. The problem that many enterprises are facing is the problem that failure incurrence and failure correction are separated in time and space. While failures arise in the planning and production phase, they are corrected only at the installation or at the end customer. This is why new quality management systems try to concentrate especially on the processes during planning, because the costs caused by failures rise by the factor of ten in every following production process. The modern Quality Management can be seen as a strategy used to enhance companywide processes in order to raise the produced quality, lower the needed time and lower the overall costs. Because costs and quality go hand in hand during production processes.[12]

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[10] Cf. DEPARTMENT-OF-TRADE-AND-INDUSTRY: Quality Management Systems - From Quality to Excellence, United Kingdom [n.d.].

[11] Cf. DEPARTMENT-OF-TRADE-AND-INDUSTRY: Quality Management Systems - From Quality to Excellence, United Kingdom [n.d.].

[12] Cf. SCHMITT, R.; PFEIFER, T.: Qualitätsmanagement, München/Wien 2010, p. 7ff.

2.1.1 Cost of poor quality

In order to justify all the efforts put into quality measures, Juran[13] 1951 already discussed the thematic of costs arising because of poor quality and the “Break-Even” in Quality costs. He described failure costs as “gold in the mine” that only waits to be brought to light. He made the subdivision evitable and inevitable costs of quality. Money spend for prevention, inspection, samples, sorting and other control procedures where inevitable costs. Evitable costs on the other hand are money spend in production failures, damaged material, rework, complaints and customer migration. This separation also emphasized that failures raised during planning cause disproportionate costs later during production.[14]

The common thinking developed as already said with the assumption that higher quality can be achieved through higher extended quality checks and this would mean higher costs. But this has shown not to be the truth. Higher quality means better productivity thus lower costs of the total processes. The problem of the old perception was that only the products quality was observed, but not the whole process of how the quality develops. Different examples show what changes can be made by improving the processes and the product’s quality.[15]

By improving the processes we get:

- Better machine load
- Shorter cycle times
- Lower stock
- Better product quality
- Less rejections and rework

By improving the product quality we get:

- Better functionality and reliability
- Less failure costs due to warranty issues
- Less failure removing costs
- Higher customer satisfaction

[13] JURAN, J.M.: Quality Control Handbook, New York 1951.

[14]Cf. SCHMITT, R.; PFEIFER, T.: Qualitätsmanagement, München/Wien 2010, p. 28.

[15]Cf. HUMMEL, T.; MALORNY, C.: Total Quality Management, München/Wien 2002.

Figure 2-3 shows figuratively how the increase of quality at the same time decreases costs.[16]

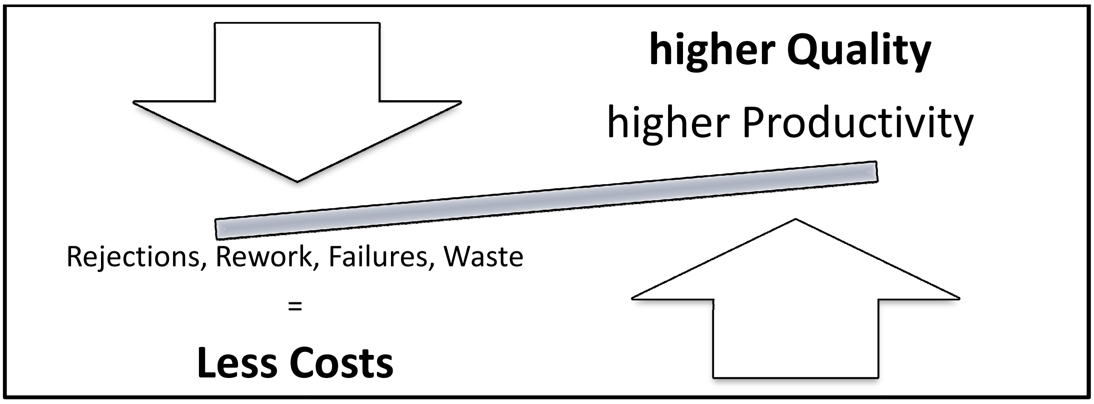

Figure 2-3: New perception: higher quality costs less[17]

To determine what costs can be related to quality we have to establish a differentiation. Only by this it is possible to know more about the source of the risen costs. Rothlauf classifies 4 types of costs, and shows what operations cause which costs[18]:

1. Costs of prevention (Conformity costs): Costs incurred during the analysis and removal of the causes of nonconformities like Audits and FMEA teams.
2. Inspection Costs (Conformity costs): Costs incurred by scheduled inspections which are not carried out due to the discovery of nonconformities.
3. Internal failure costs (Non-conformity costs): Costs that occur as a result of errors in products and services, which are detected before the output reaches the customer. In other words, it is the cost that the company bears in rectifying an error, in waste, in rejections and material inspections.
4. External failure costs (Non-conformity costs): Costs incurred because the external customer is supplied with an unacceptable product or service. This can be warranty costs, recall procedures and defective stock.

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[16] Cf. HUMMEL, T.; MALORNY, C.: Total Quality Management, München/Wien 2002.

[17] Cf. HUMMEL, T.; MALORNY, C.: Total Quality Management, München/Wien 2002.

[18] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004, p. 90.

With this differentiation the right classification of the costs can be performed and assigned to one or the other. This accurate information helps the management detect savings and improve their processes.

What a difference it can be for the companies that focus on failure prevention instead on failure correction, shows Figure 2-4 on quality costs. The first column shows the costs of a conventional Quality Management System focusing on failure correction, the second one shows the costs raised in a modern QM environment that focuses on failure prevention. By spending more on failure prevention the costs at the end of the day are. If the quality costs add up to 10% of the company's sales, savings of 3% of total sales can be achieved.[19]

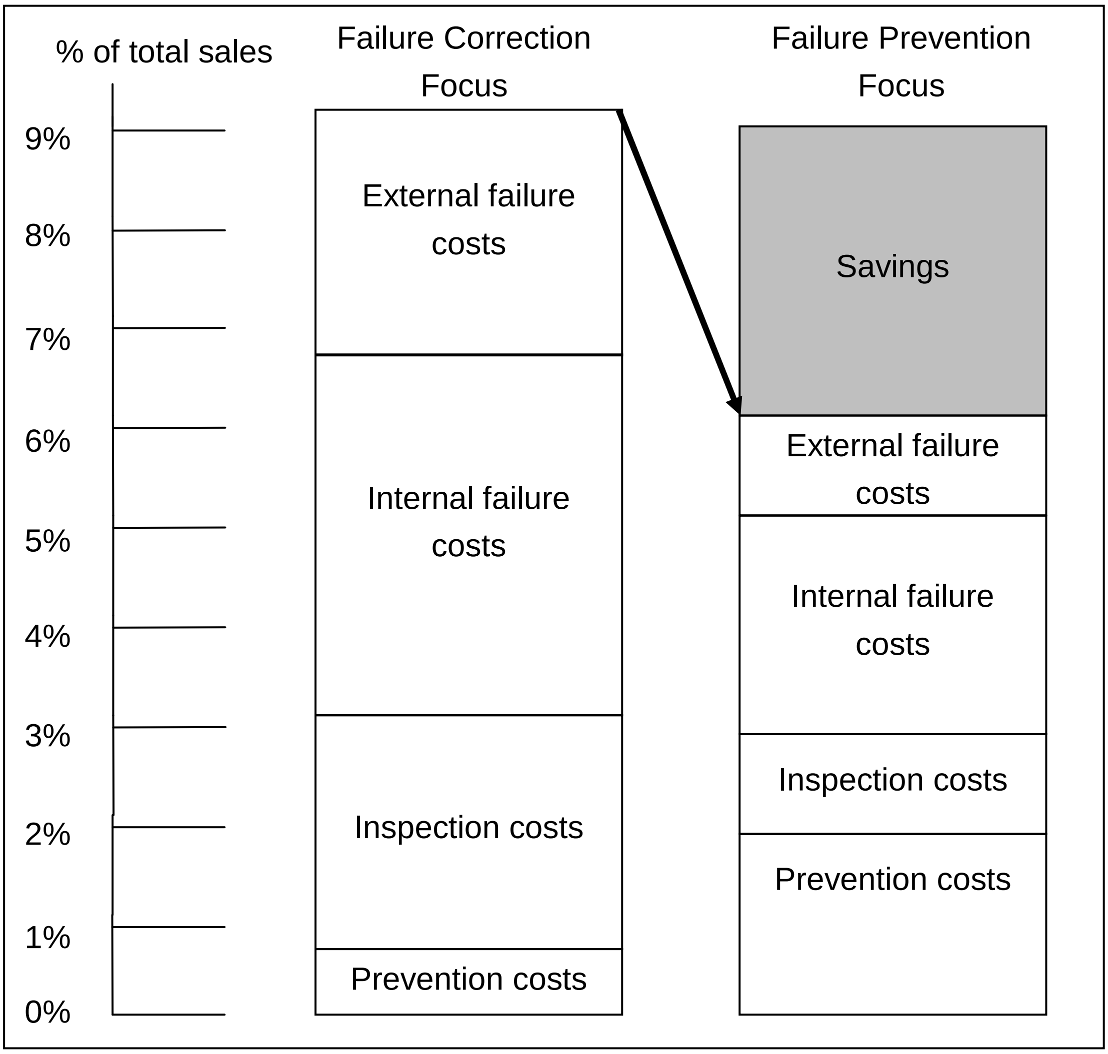

Figure 2-4: Quality Cost Savings according to Simon

[19] Cf. SIMON, W.: Die neue Qualität der Qualität - Grundlagen für den TQM- und Kaizen Erfolg, 2nd edn, Offenbach 1996.

Also Deming showed how the improvement to the company's processes affects positively the competitiveness on the market. Deming's quality chain reaction (Figure 2-5) shows the positive effects of quality to the company's financial situation.[20]

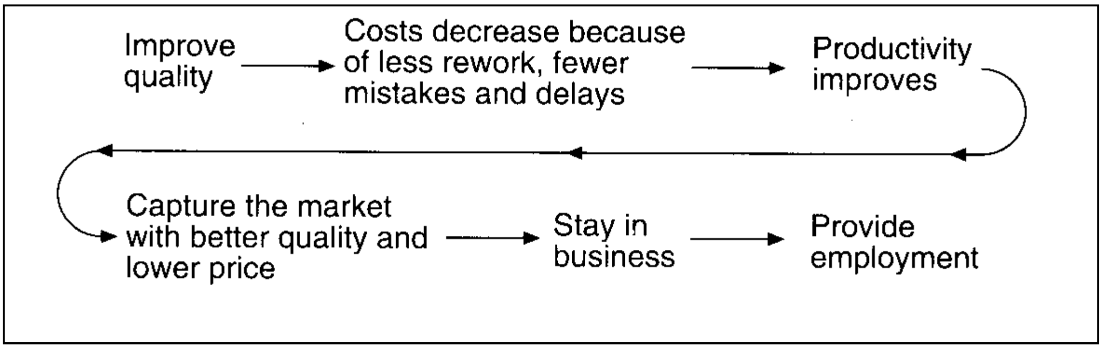

Figure 2-5: Deming's Quality Chain Reaction[21]

An abbreviation of the chain is not possible. Who tries to start with lower costs without improvement will only have short-term profits. Who wants fast results should not start with a Quality Management System. It takes more time to improve the company's processes and attitude, but a good QMS will provide positive results in the long-term.[22]

Although the prevention costs will increase in the beginning, it has to be seen as an investment that will pay off over time. Exactly the bigger investment in prevention and process improvement made it possible to save money. The main focus in Quality Management should therefore be on the prevention of failures instead of on the correction of failures. "Every Euro, which is invested in failure prevention, will save several Euros for failure correction"[23].

Another Japanese saying emphasizes the importance of a good Quality Management for cost saving: "Quality and Reliability have priority; Profit is the natural consequence of a high-quality product"[24].

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[20] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004.

[21] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004.

[22] Cf. ZOLLONDZ, H.D.: Grundlagen Qualitätsmanagement, 2nd edn, München 2006.

[23] TÖPFER, A.; MEHDORN, H.: Total Quality Management: Anforderung und Umsetzung im Unternehemen, 4th edn, Berlin 1995, p. 18.

[24] SIMON, W.: Die neue Qualität der Qualität - Grundlagen für den TQM- und Kaizen Erfolg, 2nd edn, Offenbach 1996, p. 75.

2.1.2 Main functions of QM

The Quality Management (QM) can be split up in different functions as shown in Figure 2-6. The Quality Management is supported by the Quality Policy and the Quality Improvement in order to perform the functions of planning, control and assurance.

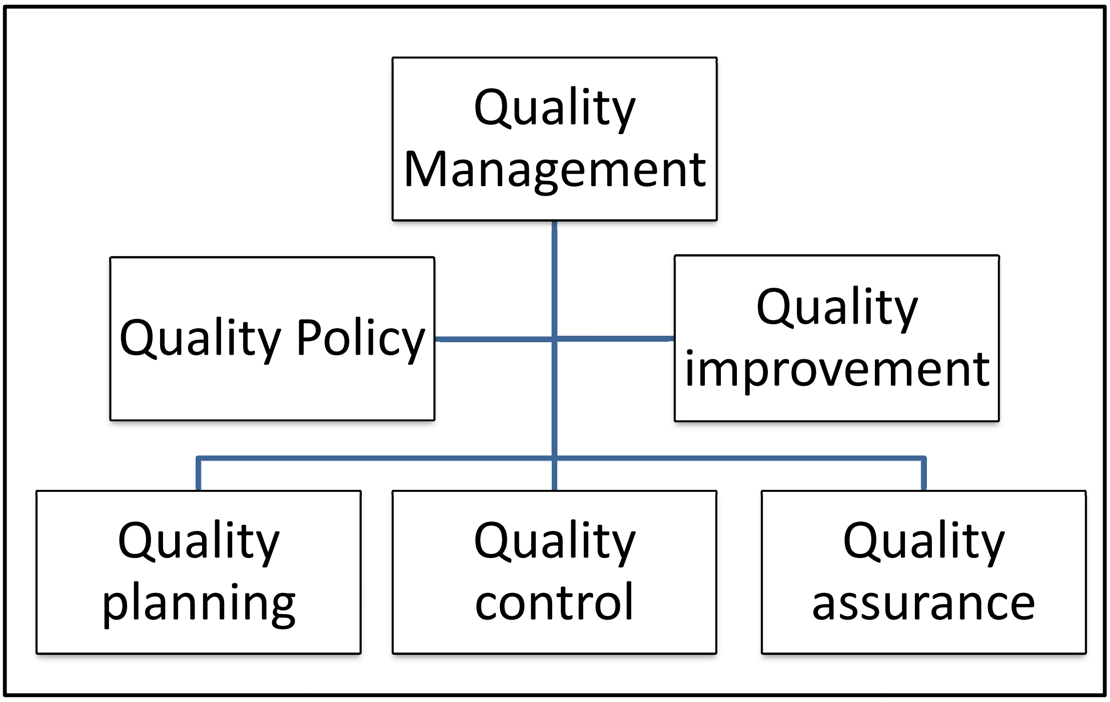

Figure 2-6: Main functions of Quality Managements[25]

The five main functions of QM are the following:

- Quality policy (QP)
- Quality improvement (QI)
- Quality planning (QPL)
- Quality control (QC)
- Quality assurance (QA)

These functions are described in the next chapters.

[25] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-9.

2.1.2.1 Quality Policy

Quality Policy is defined as: “Top management's expression of its intentions, direction, and aims regarding quality of its products and processes.”[26] The Quality Policy contains the aims and goals of a company in matters of the products quality. The management has to fully stand behind his aims. By subscribing the set up Quality Policy, the management underlines his willingness to support all effort for quality purpose and to lead the way towards a quality oriented company.[27]

2.1.2.2 Quality Improvement

Quality Improvement is defined as: “Systematic approach to reduction or elimination of waste, work-back flow, rework, and losses in production process.”[28]

The continuous improvement of the company’s quality should be permanently followed in order not only to improve the products quality but also the processes involved during daily business. Promotion of quality can be followed with the following measures in and outside the company[29].

Outside the company, the quality improvement can be enhanced by:

- Instruction manual to avoid improper usage of the product that could lead to damages.
- Warranty

Inside the company, the quality improvement can be enhanced by:

- Systematical approach to avoid failures (Zero-Defects-Program)
- Use of modern Quality Information systems
- Training of employees for self-inspection
- Implementation of an internal Suggestion System
- Set up internal Quality groups (Quality Circles)

Especially Continuous Improvements are one of the most used and effective methods to improve the Quality. And a good Quality Management system

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[26] BUSINESS-DICTIONARY: Definitions <http://www.businessdictionary.com/definition/quality-policy.html> accessed January 2011

[27] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-9.

[28] BUSINESS-DICTIONARY: Definitions <http://www.businessdictionary.com/definition/quality-policy.html> accessed January 2011

[29] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-13.

that wants to survive on the long term needs continuous improvements in every area of the company.

"Who stops to become better than good, has stopped to be good."[30]

The Japanese term KAIZEN is a frequently used term in Quality Management. It means "improvement" or "change to the better". It is not a technique or a model, but it is a synonym for the never ending continuous improvement process. The path of Continuous improvements takes endurance and consequent planning until it becomes a natural daily process. Every employee, alone or in groups, should have the possibility to show improvement potentials inside and outside his work area. The management has to establish a work environment that facilitates continuous improvement and creates a corporate culture where every employee is willing to continuously improve his workplace. To start with an improvement a measurable goal has to be established in order to set up a plan how to achieve the improvement. It is important that the affected employees should always be integrated in the problem solving process as well. A flexible approach to the solving process should be applied, without neglecting the planned completion date.The systematical approach, set up by W.E. Deming, is called the PDCA-Circle as shown in Figure 2-7.[31]

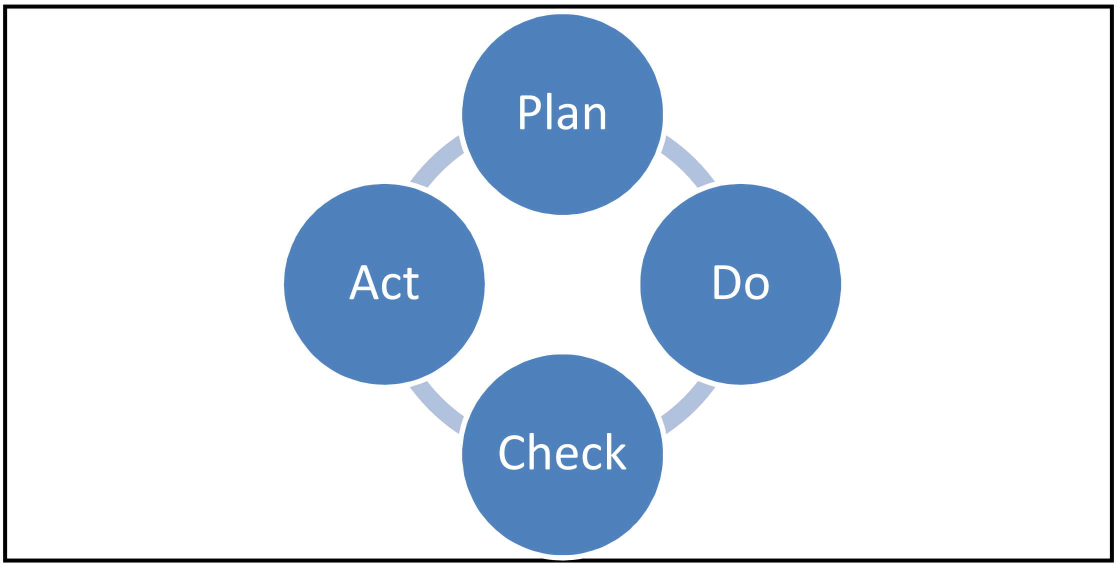

Figure 2-7: The PDCA-Circle according to Deming

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[30] ROSENTHAL, P:, 1916-2001.

[31] Cf. BRUNNER, F.: Japanische Erfolgskonzepte, Wien 2008, p. 6ff.

The Deming Circle describes the 4 steps that have to be performed in order to improve a process or product. After going through every cycle with the different criteria, the new idea can be implemented or discarded. After that the cycle will start again, turning continuously, like the process says.[32]

The four steps Plan, Do, Check, Act describe[33]:

- PLAN: Establish the objectives and processes necessary to deliver results in accordance with the expected output.
- DO: Implement the new processes on a small scale for the beginning, if possible.
- CHECK: Measure the new processes and compare the results with the expected results to ascertain any differences.
- ACT: Analyze the differences to determine their cause. Each will be part of either one or more of the P-D-C-A steps. Determine where to apply changes that will include improvement.

The circle symbolizes, that there is no ending in the continuous improvement process. One improvement follows the other. Processes change and adapt to their environment continuously in order to perform always in the most efficient way and deliver high quality products.

2.1.2.3 Quality Planning

Quality Planning is defined as: “Systematic process that translates quality policy into measurable objectives and requirements, and lays down a sequence of steps for realizing them within a specified timeframe.”[34]

How the quality of the product or a service will be at the end is already defined at the very beginning with the concept and the design. That’s why Quality Measures have to be planned and followed already during the R&D phase of a product. Furthermore also all the other departments like marketing, stores and purchase have to perform QPL activities in order to

[32] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004, p. 42.

[33] Cf. HUMMEL, T.; MALORNY, C.: Total Quality Management, München/Wien 2002, p. 82.

[34] DEPARTMENT-OF-TRADE-AND-INDUSTRY: Quality Management Systems - From Quality to Excellence, United Kingdom [n.d.].

fulfill the goals mentioned in the QP. Wohinz structures Quality Planning in the following steps[35]:

- Planning according the product: determine goals and quality requirements
- Planning according Management tasks: set up a plan of procedure for the QMS
- Setting up QM-Plans as well as quality improvements

The quality planning is the base for the out coming quality at the end of the processes and has therefore to be performed with attention.

2.1.2.4 Quality Control

Quality Control is defined as: “Subset of quality assurance (QA) process, it comprises of activities employed in detection and measurement of the variability in the characteristics of output attributable to the production system, and includes corrective responses.”[36]

In Quality Control different methods and techniques are used with the purpose of supervising a process and prevent bad quality from occurring in all steps of production. Tree tasks are performed during Quality Control. The first task is the inspection of the product itself. It is performed at the beginning in the goods receipt area, during the manufacturing process and at the final stage before dispatch. The second task is the process control. It concentrates on supervising and monitoring the different ongoing processes. The last task is the detection and elimination of customer service problems. The quality management concentrates on the fulfillment of customer needs. That’s why the quality control has to detect new customer requirements and eliminate the problems that could reach the end consumer. Quality tools are here used to enhance the process.[37]

Quality Control Tools

In order to support the Continuous Improvement in the company, different QC-Tools are used. They help during finding, analyzing and solving of

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[35] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-9f.

[36] BUSINESS-DICTIONARY: Definitions <http://www.businessdictionary.com/definition/quality-policy.html> accessed January 2011

[37] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-10ff.

problems. These elementary auxiliary tools can be extremely helpful when used properly. They are used to:[38]

- Gain data and detect failures
- Perform failure and root cause analysis
- Prevent failures and analyze improvements

Brunner describes 7-Quality Control Tools[39]:

1. Cause-and-effect diagram: The Cause-and-effect diagram (also called Ishikawa or fishbone chart): a problem can often have different causes that are connected to each other in a certain way. With the help of this method it is possible to identify many possible causes for an effect or problem and sort ideas into useful categories. The usage of it is very simple: the solution to a problem should be found. By adding more and more possible causes the finding of the solution to the problem can be facilitated. Therefore different possible categories of causes are identified. For technical problems of the "4-M Method" is used (see Figure 2-8). The 4 M stand for Machine, Material, Method and Human (Mensch in German).

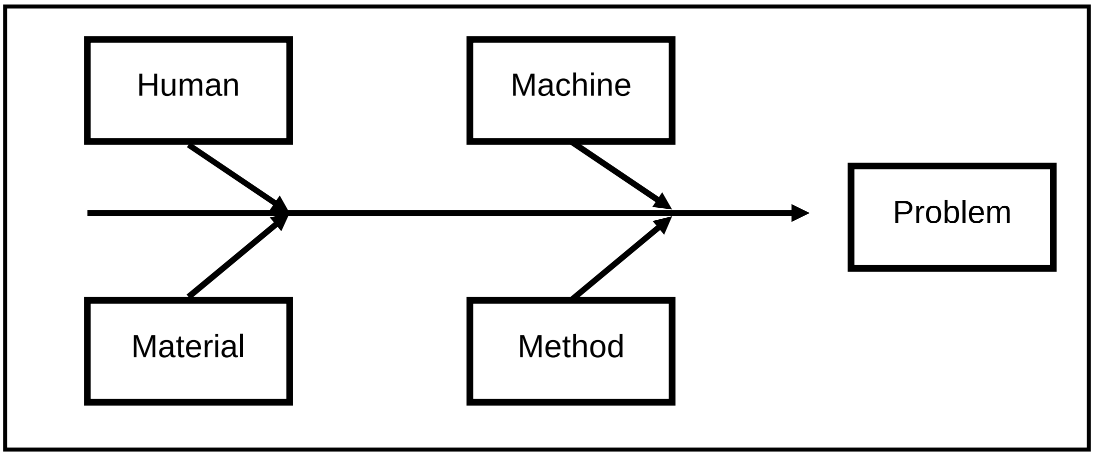

Figure 2-8: Ishikawa Diagram (own illustration)

2. Check sheet: A structured, prepared form for collecting and analyzing data; a generic tool that can be adapted for a wide variety of purposes.
3. Control charts: Graphs used to study how a process changes over time. Boundaries can be set to monitor if the process stays in given

[38] Cf. BRUNNER, F.: Japanische Erfolgskonzepte, Wien 2008, p. 12ff.

[39] Cf. BRUNNER, F.: Japanische Erfolgskonzepte, Wien 2008, p. 13.

tolerances. If this are exceeded the process can be driven into the right direction again.

4. Histogram: The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs in a certain period. It facilitates the interpretation of a huge amount of data collected over time. By adding target values and limits of tolerance, the distribution of the process can be identified and regulated.
5. Pareto chart: the Pareto chart (see Figure 2-9) helps to identify which cause has the biggest effect on the problem. This helps to determine in which sequence the causes have to be removed in order to have the biggest effect. It is based on the Pareto principle that says that 80% of the consequences derive from 20% of the possible causes. This means that by removing only 20% of the causes, 80% of the consequences causing the problem can be removed.

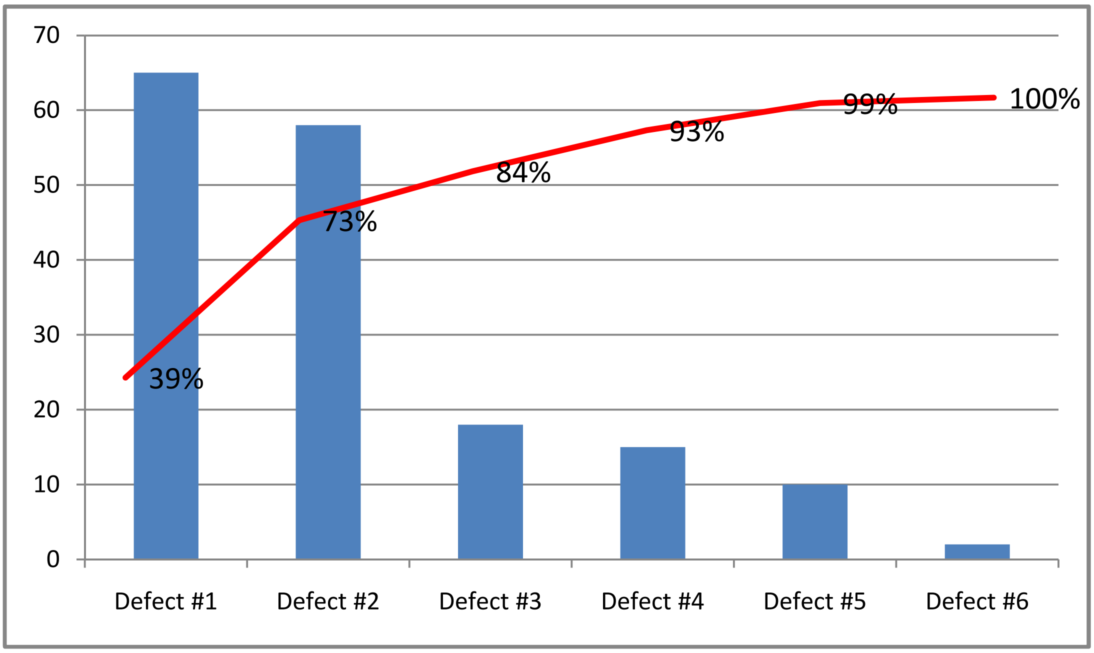

Figure 2-9: Pareto chart (own illustration)

6. Scatter diagram: it displays the correlation between two variables with pairs of numerical data. The relationship between the two variables can be identified by observing the pattern given resulting from the data.
7. Stratification: A technique that separates data gathered from a variety of sources so that patterns can be seen (some lists replace "stratification" with "flowchart" or "run chart").

In TQM, where the core process is problem solving, this tools should be used regularly during quality improvement. In order to do so it is necessary to arm each and every employee in the organization with basic and effective tools that will help problem solving at all levels based on a database.[40]

2.1.2.5 Quality Assurance

Quality Assurance is defined as: "Often used interchangeably with quality control (QC), it is a wider concept that covers all policies and systematic activities implemented within a quality system. QA frameworks include (1) determination of adequate technical requirement of inputs and outputs, (2) certification and rating of suppliers, (3) testing of procured material for its conformance to established quality, performance, safety, and reliability standards, (4) proper receipt, storage, and issue of material, (5) audit of the process quality, (6) evaluation of the process to establish required corrective response, and (7) audit of the final output for conformance to (a) technical (b) reliability, (c) maintainability, and (d) performance requirements."[41]

In short, the task of the Quality Assurance is to provide the confidence that quality requirements are fulfilled.

Wohinz describes 6 techniques how to achieve quality assurance[42]:

- verification of the quality of produced products to ensure that the quality is within the specified boundaries
- saving all quality-related data
- detecting failures and analyze them
- certify products and systems in order to see if they meet the existing directives and standards
- quality decision: approval to use nonconforming products in special occasions

[40] Cf. NETWORK, CiteMan: QC-Tools <http://www.citeman.com/530-quality-control-tools-for-tqm/> accessed December 2010

[41] BUSINESS-DICTIONARY: Definitions <http://www.businessdictionary.com/definition/quality-policy.html> accessed January 2011

[42] Cf. WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 8-12ff.

- performing a quality-audit to obtain records and relevant information and asses those objectively to determine the extent to which specified requirements are fulfilled. A quality-audit is performed on systems, processes and products as shown in Figure 2-10:

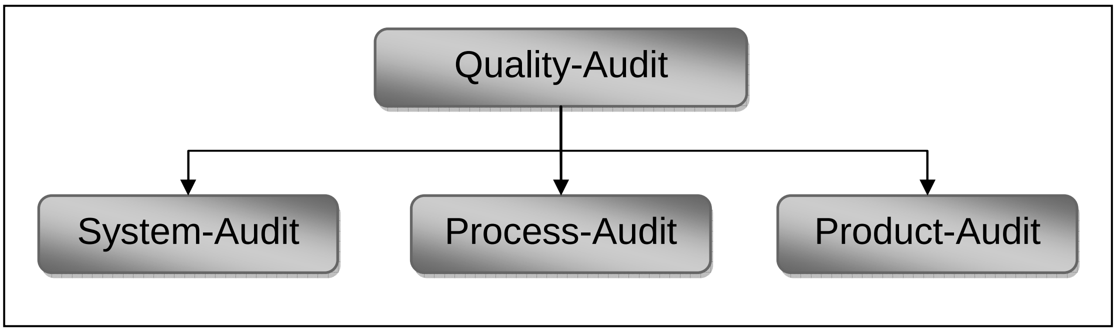

Figure 2-10: Characteristics of a Quality-Audit (own illustration)

It is always important to keep the quality at a high level. Improved processes should not drift back to initial stages. And this is one of the most important topics, not drift back to old habits. That's why the Quality Assurance has the role to control, maintain and standardize implemented improvements.

Based on this Quality Management Basics different QMS developed over the last decades. Different personalities had a great impact on the development of different Systems and changed the way how Quality is seen and lived today.

2.2 History of Quality Management

The development of quality philosophy goes back to the Babylonian Kingdom 1700 BC, where it is first documented, that bad quality was punished by law. In fact, the code of Hammurabi says: "If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then the builder shall be put to death."[43]

Also the building of pyramids called for exact measurement. In an Egyptian work of art an inspector can be seen supervising the making of building blocks. However, it was not until the breakthrough of mass production during

[43]Cf. Translated by King, L.W.: 'The Code of Hammurabi', in: Exploring Ancient World Cultures, http://eawevansville.edu/anthology/hammurabi.htm, accessed 10 January 2011

the industrialism that systematic methods of quality control were used by using statistical methods.[44]

In the 1930's Dr.W.A.Shewhart of the Bell Laboratories started with the industrial application of the control chart. The Second World War then was the catalyst that made the control chart's application possible to various industries in the United Sates. By utilizing quality control, however, the United States was able to produce military supplies inexpensively and in large quantity. Certain statistical methods researched and utilized by the allied powers were so effective that they were classified as military secrets until the surrender of Nazi Germany.[45]

The biggest evolution of Quality Management Systems in the years from 1940 to 2000 took place in Japan. Japan was devastated by the defeat in the Second World War. Practically all of its industries were destroyed, and there was no food, clothing or housing. When the U.S. Occupation forces landed in Japan, they were immediately faced with major failures in telephone services. The problem was not merely due to the war that had just been fought; the quality of equipment was uneven and poor. Knowing these defects, the U.S. Forces ordered the Japanese telecommunication industry to begin the use of modern quality control, and took steps to educate the industry. This was the beginning of statistical quality control in Japan. They taught Japanese industry straight out of the American method without making any modifications appropriate for Japan. This created some problems but the results were rather promising. In management, Japan also lagged behind, using the so called Taylor method in certain quarters. Quality control was totally dependent on inspection and not every product was sufficiently inspected. In those days Japan was still competing with cost and price but not with quality, it was still the age of cheap and poor products.[46]

During this period the national standards system JIS came into being. This Japanese Standards Association was established in 1945. This system was instrumental in introducing and popularizing statistical quality control in Japanese industries. Furthermore a private organization formed a union of Japanese Scientists and Engineers (JUSE) consisting out of engineers and

[44]Cf. BECKER ; PLAUT; RUNGE: Anwendungen der Mathematischen Statistik auf Problem der Massenfabrikaten, Berlin 1927.

[45]Cf. BERGMAN, B.; KLEFSJÖ, B.: Quality, Lund 1994.

[46]Cf. NATARAJAN, TR; PIO, E.: Quality Samurai, Mumbay 1997.

scholars in 1946. Its aim was to engage in research and dissemination of knowledge of quality control. The members sought a means of rationalizing Japanese industries, of exporting quality products overseas, and of raising the living standards of the Japanese people. To accomplish this, they wanted to apply quality control of Japanese industries. The Quality Control Research Group held seminars for the Japans industry and tried to build up awareness about quality control upon japans industry. Nowadays still seminars are held by JUSE, who was sure one of the driving forces of the development of Total Quality Management (TQM).[47]

The evolution during the last 50 years was also due to big personalities who made it possible to achieve such great results in the development of new quality management systems: above all William E. Deming, Joseph M. Juran and Kaoru Ishikawa. Without them TQM would not have developed to be a so successful tool throughout the industry worldwide.

2.2.1 William E. Deming

Deming is seen as the father of the quality movement in Japan. JUSE honored his efforts by establishing the DEMING Award that is given yearly to companies with outstanding improvements in the field of quality (see 2.3.3 Quality Awards).[48]

William Edwards Deming was born in 1900 in the United States of America. He graduated from Yale University (1928) after the completion of two graduate degrees in Mathematics and Physics. In 1927 Deming was introduced to Walter A. Shewhart of the Bell Laboratories, the founder of the statistical control of processes and the control chart. Deming was influenced by his theories and saw that these ideas could be applied not only to manufacturing processes but also to management processes. This application of processes made it possible that Deming had such a big influence on the industrialized world after 1950.[49]

Deming emphasizes the importance of the top management role. He believes, like Juran, that only if the top managements itself totally commit to the quality issues it is possible to achieve continues quality improvements.

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[47]Cf. SRINIVASU: Total Quality Management Awareness Program, Gummidipoondi 2009.

[48]Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004.

[49]Cf. SRINIVASU: Total Quality Management Awareness Program, Gummidipoondi 2009.

Furthermore he presented his 14 point management list. It reflects what we today interpret as a Japanese leadership ideal. Deming says that the 14 points have a general applicability.[50]

1. Create constancy of purpose for improvement of product and services
2. Adopt the new philosophy
3. Cease dependence on mass inspection
4. End the practice of awarding business on price tag alone
5. Constantly and forever improve the systems of production and services
6. Institute modern methods of training on the job
7. Institute modern methods of supervision and leadership
8. Drive out fear
9. Break down barriers between departments
10. Eliminate numerical goals for the work force
11. Eliminate work standards and numerical quotas
12. Remove barriers to pride of workmanship
13. Institute a vigorous program of education and training for everyone
14. Create a structure in top management that will push every day on the above 13 points.

2.2.2 Joseph M. Juran

Immigrated in the USA as a poor Romanian, Juran established himself in the world of quality control and became one of the leading experts in the field. During his first working years, he got the chance to work together with other Quality Control pioneers at Bell Laboratories in a program to implement new tools and techniques in the company. Throughout his career he has made many contributions to the fields of quality control and quality management. He affected the entire world with his devotion to quality management.[51]

Juran’s definitions of quality:
In his book Quality Control Handbook, he tells that there are two meanings of the word quality, causing confusion to the people that use them.

[50] Cf. BERGMAN, B.; KLEFSJÖ, B.: Quality, Lund 1994.

[51] Cf. NESTOROVIC, D. ; RODRIGUEZ, G.; KROH, M.: IOWA State University: Joseph M. Juran <http://www.public.iastate.edu/~vardeman/IE361/f02mini/kroh.pdf> accessed December 2010

"Quality means those features of products which meet customer needs and thereby provide customer satisfaction. In this sense, the meaning of quality is oriented to income. The purpose of such higher quality is to provide greater customer satisfaction and, one hopes, to increase income. However, providing more and/or better quality features usually requires an investment and hence usually involves increases in costs. Higher quality in this sense usually costs more."[52]

"Quality means freedom from deficiencies-freedom from errors that require doing work over again (rework) or that results in field failures, customer dissatisfaction customer claims and so on. In this sense, the meaning of quality is oriented to costs, and higher quality usually costs less."[53]

The differences of the two meanings are displayed in Table 1-1: Juran's two definitions of quality.

Juran's two definitions of quality	
Definition of Quality 1	Definition of Quality 2
Product features that meet customer needs Higher quality enables company to: - Increase customer satisfaction - Make products salable - Meet competition - Increase market share - Provide sales income - Secure premium prices - The major effect is on sales. **Usually, higher quality costs more.**	**Freedom from deficiencies** Higher quality enables companies to: - Reduce error rates - Reduce rework, waste - Reduce field failures, warranty charges - Reduce customer dissatisfaction - Reduce inspection, test - Shorten time to put new products on the - market - Increase yields, capacity - Improve delivery performance - Major effect is on costs. **Usually, higher quality costs less.**

Table 1-1: Juran's two definitions of quality

Over time, quality will pay for itself and help reduce the overall costs. You only have to look to quality costs from the right perspective. To make quality happen, Juran defines three processes that are necessary to manage for quality. The three processes combined are called the Juran

[52] JURAN, J.M.: Quality Handbook, New York 1999.

[53] JURAN, J.M.: Quality Handbook, New York 1999.

Trilogy and include quality planning, quality control and quality improvement. If the management focuses on these processes, they are on the right way to a TQM system.[54]

2.2.3 Kaoru Ishikawa

Kaoru Ishikawa, born in 1915, worked on the development of different group work concepts, later also known as "Quality Circles". In 1985 Ishikawa published his book "What is total quality control, the Japanese way". Six core elements are described which he uses to describe Total Quality Control (TQC):[55]

- ***Quality first:*** an enterprise that acts according to the principle of quality first, will gain the confidence of the customer continuously, what will lead to a positive development of the company on the long therm.
- ***Quality means conformance to consumer's requirements:*** it is the belief of the Japanese that quality is defined only by the customer. New techniques like Quality function deployment underline this thinking.
- ***The involvement of all important functions:*** The idea taken from Feigenbaum implies that multifunctional teams have to form a multifunctional management in order to fulfill customers' needs.
- ***Continuous Improvement:*** all measures to improve quality continuously aim for perfection. All stages that are already reached are not yet optimal and can be further improved. Because perfection can never be achieved, the process of continuous improvement is endless.
- ***The integration of all levels:*** this element is connected to the Japanese development of Quality Circles. It aims for further education of all levels inside the company.
- ***Consideration of the social system:*** according to Ishikawa, companies exist only for the purpose to fulfill the needs of the people. This should be their primary goal according to the Japanese. Everyone who has the opportunity to work in or with a company should therefore try to give his best and evolve his potential.

[54] Cf. ZOLLONDZ, H.D.: Grundlagen Qualitätsmanagement, 2nd edn, München 2006, p. 92 ff.

[55] Cf. ZOLLONDZ, H.D.: Grundlagen Qualitätsmanagement, 2nd edn, München 2006, p. 113ff.

Furthermore Ishikawa developed a quality control tool named after him: the Ishikawa diagram (see 2.1.2.4 Quality Control).

2.3 From Inspection to Business Excellence

Globalization has brought in an ease of unprecedented competition from domestic companies as well as multinationals. This brings substantial benefits to customers in terms of quality and price but puts existing companies under pressure to perform better at all levels to deliver quality goods and service at an affordable price. This is why a large number of companies decided to go with different Quality Management Systems, in order to facilitate the process of attaining excellence in quality and service. This led to an evolution of the different Systems in different continents of the world together with the devotion of Quality Management Gurus as discussed in chapter 2.2 History of Quality Management.

The way of living the Quality philosophy evolved over different steps from the normal inspection to a World Class Quality management system [56]:

- Inspection performed by the foreman
- Good/bad sorting; final inspection
- Sample inspection
- Quality Assurance
- Quality Management ISO 9000
- Companywide, Total Quality Management
- World Class Quality; Business Excellence

The first big step to standardize and implement a QMS in a large amount of enterprises was the DIN EN ISO 9000 series. In the 90's this certification was one of the most discussed topics.

2.3.1 ISO 9000 – Quality Management Standard

The ISO 9000 family of standards relate to quality management systems. It consists of tree norms[57]:

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[56]Cf. BRUNNER, F.; WAGNER, K.: Qualitätsmanagement, 4th edn, München/Wien 2008, p. 6f.

[57]Cf. PFITZINGER, E.: Der Weg von DIN EN ISO 9000 zu Total Quality Management (TQM), Berlin/Wien/Zürich/Beuth 2002, p. 13ff.

- ISO 9000 – fundamentals of quality management systems
- ISO 9001 - Quality management system requirements
- ISO 9004 - Managing for the sustained success of an organization: A quality management approach

The ISO 9001 standard forms the basis of the Quality Management. Every company however is free to adapt it to its needs. The standard also serves as the basis for certification. The requirements of the norm can be simplified into four topics:

- There has to be one or a group of people that deal with the thematic of quality
- It defines, that operations have to be defined and implemented
- Some operations have to be implemented
- The norm defines, how the efficiency of the QM-Systems and the processes has to be monitored and controlled

Another important characteristic of the ISO 9001 norm is the process orientation. Processes are seen as the perfect instrument to organize and structure an organization. The strong emphasis on processes shows also the model of the Quality Management System in the DIN EN ISO 9004:2000 shown in Figure 2-11.

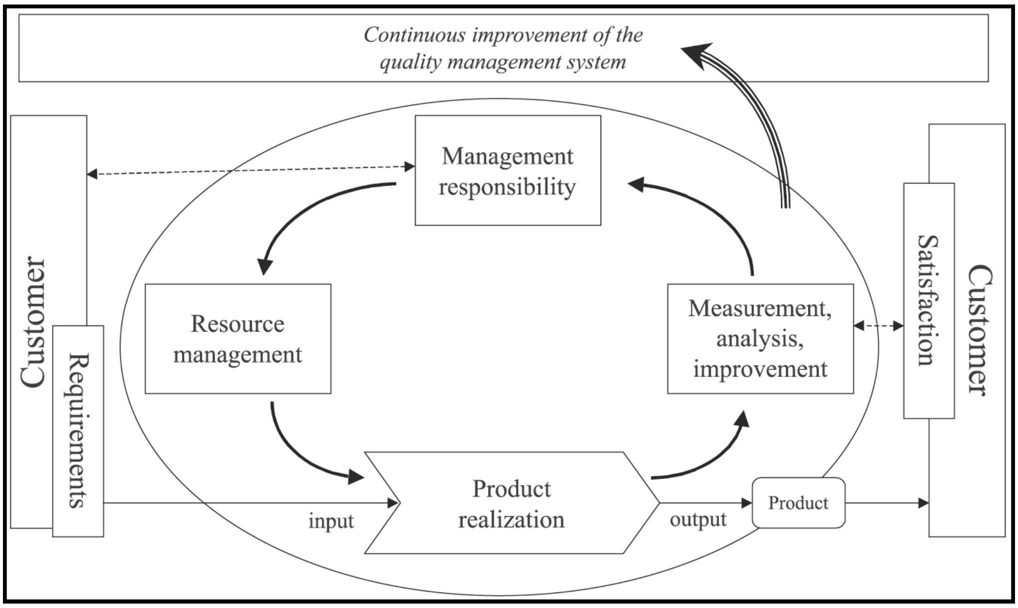

Figure 2-11: Model of a process-based Quality Management System according to DIN EN ISO 9004:2000-12[58]

[58] DIN: DIN EN ISO 9004:2000-12, Berlin 2000.

With the help of process control, the creation of quality can be ensured and controlled over the different production steps.

2.3.2 Total Quality Management

As of now it is almost impossible to survive on some markets without having the own processes assessed according to the newest ISO 9001 certification. The group of businesses assessed to meet the requirements of ISO 9001 can be divided in two groups:

- Companies with a living Quality Management System
- Companies with an ineffectual, bureaucratic implemented system

The first group gained a lot from the implementation, has established a transparent workflow management and is continuously improving. The second one got disappointed and frustrated. A QM-System was implemented, but the reality shows that the processes are not lived as described and the system is only shown for the yearly audit. [59]

Both groups now tend to search for further improvement of their Quality Management or for an appropriate alternative. The first group wants to further evolve their system, the second group to start over again because they do not believe in the old system anymore. When searching for the next step in Quality Management the most followed strategy is the Total Quality Management approach nowadays. To aim for less would be fatal if the company wants to survive in the so competitive worldwide market. Total Quality Management means complete action towards quality amongst the whole business. Every employee is responsible for quality and effort in continuous improvement of all aspects in the organization. A TQM will interact with all activities of the organization, from customer needs to customer satisfaction.

2.3.2.1 Definition of TQM

TQM can be defined as a management method based on the collaboration of all company members, which focuses on quality and on the satisfaction of the customers and aims for the company's success as well as for the benefit of

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[59] Cf. PFITZINGER, E.: Der Weg von DIN EN ISO 9000 zu Total Quality Management (TQM), Berlin/Wien/Zürich/Beuth 2002, p. 3ff.

the employees in the long term. In the denomination TQM, every letter stands for a significant meaning.[60]

- "T" for Total, it means involve all the employees, suppliers and customers in the quality system.
- "Q" for Quality, quality of the work, processes and the company, from which high quality products will develop automatically.
- "M" for Management, that it is the responsibility of the management to implement quality improving procedures and to motivate the employees for it.

DIN ISO 8402 defines TQM as a:
"Management system building on the cooperation of all the members of the company. It focuses on the quality and aims to satisfy the customer on the long term as well as the members of the company."

Above all the focus on continuous improvement is highlighted in the definition of Kanji/Asher[61].

"All work is seen as a process and total quality management is a continuous process of improvement for individuals, groups of people and whole organizations. What makes total quality management different from other management processes is the concentrated focus on continuous improvement. Total quality management is not a quick management fix; it is about changing the way things are done within the organization's lifetime."

2.3.2.2 TQM philosophy

Total Quality Management is not only a broad thinking and action approach, but more a Philosophy that has to be lived by the whole organization. High quality of the produced products and the right handling with resources are the main objectives. The implementation of a successful TQM-system requires a methodical project management and supporting organizational measures. Main focus has to be put on the involvement of all employees in the company processes. Employees have to be seen and used as resources that can deliver own thinking and ideas. Customer needs have to be fulfilled. Their

[60] Cf. HUMMEL, T.; MALORNY, C.: Total Quality Management, München/Wien 2002, p. 7.

[61] Cf. KANJI, K.G.; ASHER, M.: 100 Methods for Total Quality Management, London 1996, p. 1.

voices can deliver useful hints in which way the company should further develop their product. The third point to focus on are the procedures inside the company. They have to be documented and standardized as processes in order to ensure the right accomplishment of the orders from the customers. The TQM-approach can be summarized to tree points that can be seen as the tree pillars of TQM (see Figure 2-12).[62]

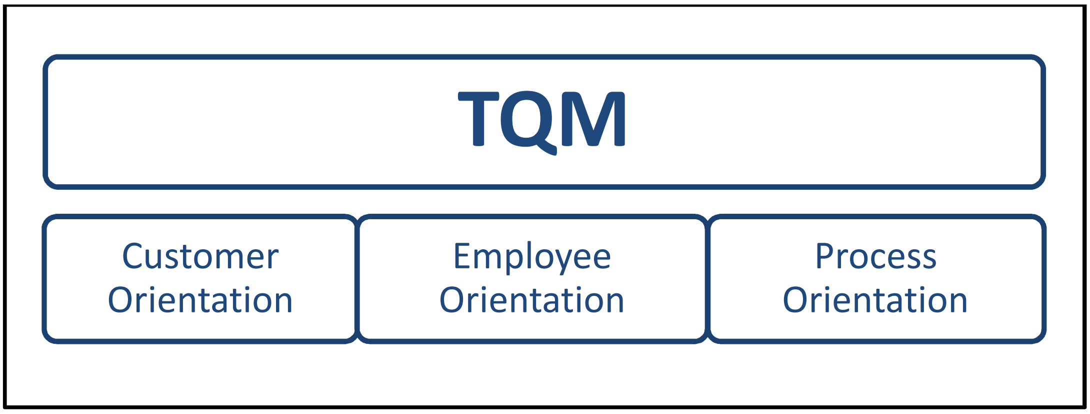

Figure 2-12: three pillars of TQM

The first pillar of Total Quality Management, Customer orientation, tries to explain who can be seen as customer and why it is so important to focus on their needs.

Customer orientation

The total quality approach specifies two different kinds of customers: internal and external customers. People tend to say that they do not have any contact with the customer unless they work in the marketing department. But every employee has an internal customer who he works for as well. If a technical engineer is working in the technical department and is responsible to create drawings for production, he is dealing with an internal customer. He has to respect the needs and expectations of the production worker. If this is not the case, there will arise some problems and the productivity will decrease. We have the same problematic when dealing with external customers. Customer needs have to be satisfied. The Japanese Noriakie Kano classified tree groups of customer's satisfaction levels with his Kano-model: excitement, performance and basic. Different attributes of the product will have a different effect on the customer's satisfaction. With time, attributes causing excitement

[62]Cf. BRUNNER, F.; WAGNER, K.: Qualitätsmanagement, 4th edn, München/Wien 2008, p. 8.

at the beginning will drift down to become a basic need. An example can be the electronic window lift. First models containing this option cause excitement for its customers, but no disappointment if not available. Nowadays it is seen as a basic need, its installation will not cause any excitement but if not available, the customer will be unsatisfied.[63]

Figure 2-13 shows the Kano model. It describes the level of excitement that a special feature of the product causes at the customer depending on the time. The red curve shows the excitement-level over the need-fulfillment-level of the installation of an electronic window lift 60 years ago. The green curve shows the excitement-level over the need-fulfillment-level of the installation of an electronic window lift nowadays.

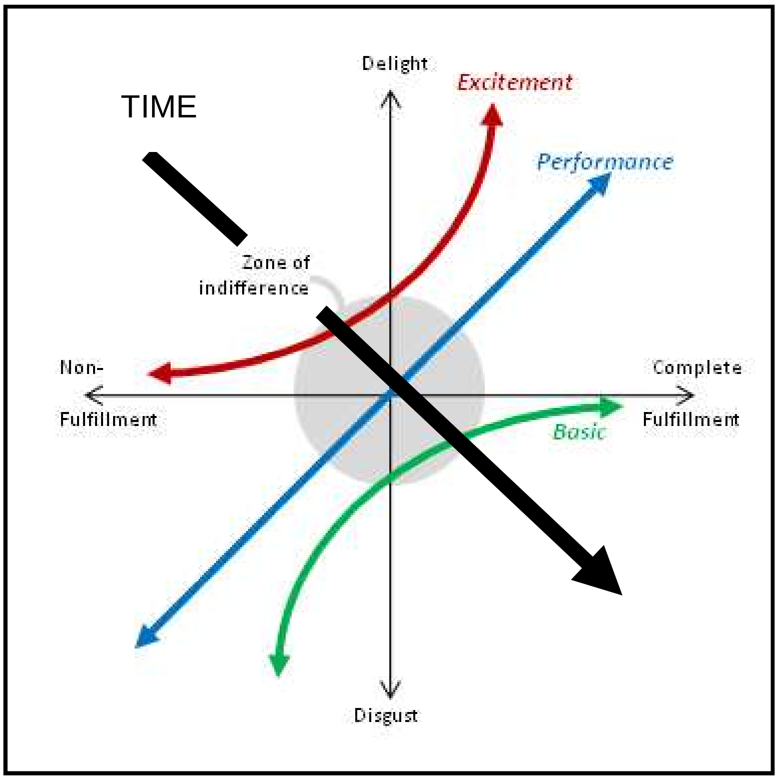

Figure 2-13: Kano-model[64]

When trying to fulfill the customer expectations the employees play an important role, because they are the ones staying in contact and dealing with them.

[63]Cf. THALLER, G.E.: Von ISO 9001 zu TQM, Berlin/Offenbach 2001, p. 60ff.

[64] CUSTOMER-ALIGNED-PRODUCTS: Kano Model <http://www.customeralignedproducts.com/kano-model/> accessed January 2011

Employee orientation

The problem solving and creativity potential of every employee should be used for company purpose as much as possible. The following goals have to be pursuit in order to achieve a successful employee orientation:[65]

- Increase the interest of the employee for his work in the company
- Utilization of the employees know-how, in order to achieve a continuous improving in all processes regarding quality and productivity
- Increase the motivation of every employee to take part in this process

This emphasizes the importance of the right strategy in human resources. When trying to save costs, the management has to focus on long term savings. It would be the wrong approach to save money for planning, training and support of human resources because they will lead to fast savings. This short term view will lead to low quality work, unsatisfied customers, financial pressure, unmotivated employees and low profits. A well paid and trained employee will need less control because of its higher motivation and this will lead to higher customer satisfaction, less financial pressure, good work environment and bigger profits in the long term.[66]

In order to ensure that every procedure is performed in the right way and to minimize possible occurring failures, the employees have to be trained to go through specified processes. A standardized process structure will allow fewer errors to occur during the development of the product. Standardization of working places also helps the company when they have to replace somebody or hire new employees. They will learn and get to know the different company processes much faster and easier.

Process orientation

The company's total activities are seen as a combination of processes and process chains. Every single activity is seen as an own process and therefore many improvements can be identified in order to raise quality and productivity. In order to optimize the processes, the single process steps

[65] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004.

[66] Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004.

cannot be seen as single segregated parts but as part of the whole process. For this we need a process oriented company.[67]

In order to build up a process oriented environment different procedures have to be analyzed, identified as processes and implemented. Wagner[68] defines a 4-step procedure for improvement and setting up of processes. The four steps are:

1. Process identification and delineation:

The actual process has to be identified with its process members, interfaces and process steps. Rethink the purpose of the process and make a first delineation by analyzing what actually is part of the process and what can be excluded.

2. Analysis of the actual process:

The actual process has to be analyzed in order to figure out what are the needed changes to bring it to the desired process.

3. Conceptual design of the desired process:

Design a new process according to the actual needs of the company as identified and delineated in step one. Also the analyzed problems found in step two have to be solved by changing the relative process steps.

4. Realization of the improvement:

Take the needed actions to implement the changes designed for the new process. Preferable the change should be doable in a short period and parallel to daily business in order to not hinder company activities.

The 4-steps-method is a Tool, which can be used for new processes during the set up of a Process oriented quality management system as well as for changing and optimizing of already existing processes. The simplicity and clarity emphasis the suitability for practical use.

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[67]Cf. ROTHLAUF, J.: Total Quality Management in Theorie und Praxis, München 2004, p. 59.

[68]Cf. WAGNER, K.: PQM - Prozessorientiertes Qualitätsmanagement, Leitfaden zur Umsetzung der ISO 9001:2000, München/Wien 2006.

The process management, as a part of the process lifecycle, can be performed using the 4 steps method as shown in Figure 2-14: Process Lifecycle according to Wagner[69].

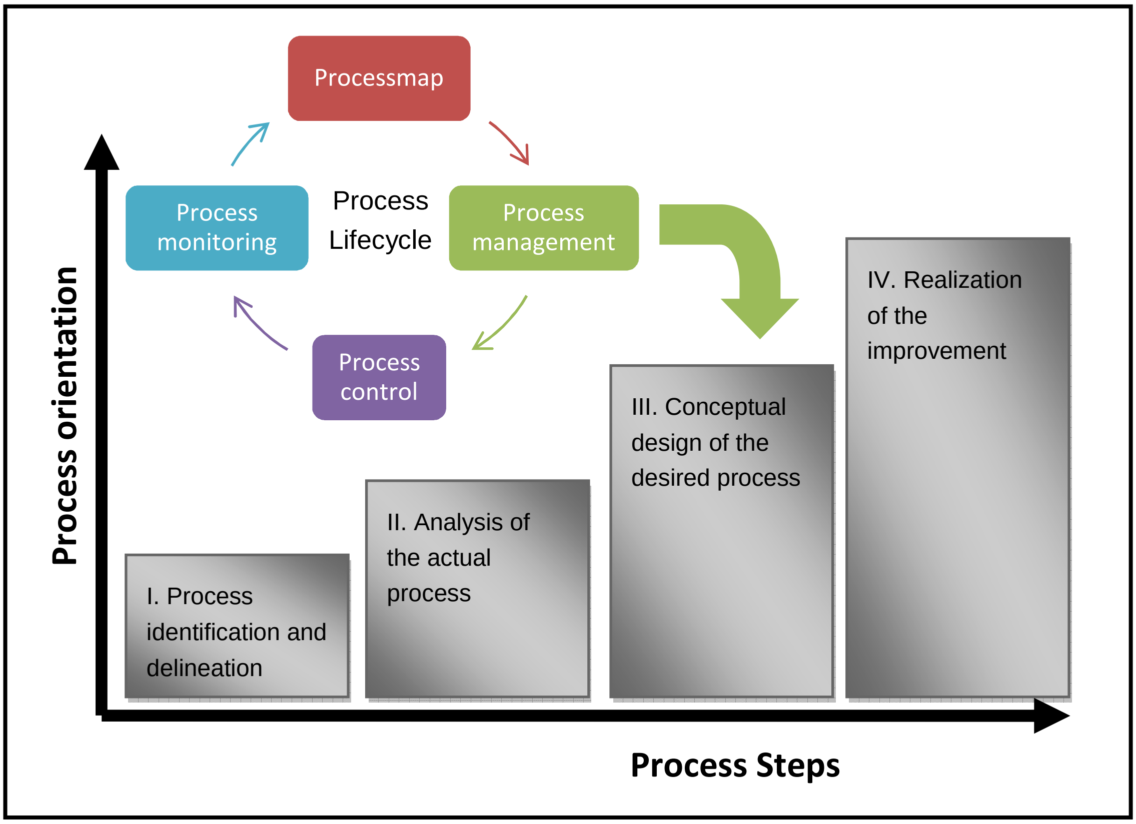


Figure 2-14: Process Lifecycle according to Wagner

2.3.3 Quality Awards

In order to enhance companies to improve in the field of quality and to evaluate their achievement, different organizations founded quality awards. They give the opportunity for benchmarking and help also to spread new ideas and approaches to Quality Management. Companies can use the feedback got from external evaluation to detect further improvement possibilities in their companies. The most important and prestigious awards are the Deming Prize, mostly known in Japan and the Asiatic countries, the

[69]Cf. WAGNER, K.: PQM - Prozessorientiertes Qualitätsmanagement, Leitfaden zur Umsetzung der ISO 9001:2000, München/Wien 2006.

Malcolm Baldrige National Quality Award in the USA and the European Excellence Award in Europe[70].

The Deming award is one of the highest quality awards across the globe. The prize is administered and awarded by the JUSE. It was established in December, 1950 in honor of Dr. W. E. Deming. It was originally designed to reward Japanese companies for major advances in quality improvement. Over the years it has grown under the guidance of JUSE, to become one of the highest awards on TQM in the world. It is presented to a company that has achieved distinctive performance improvements through the application of TQM.

[70]Cf. BRUNNER, F.; WAGNER, K.: Qualitätsmanagement, 4th edn, München/Wien 2008, p. 331 ff.

3 Practical Approach

In 2008, both Leitner Technologies and Shriram EPC set up the LSML quality policy when founding the joint venture. It includes the eager target of becoming market leader in the Indian wind energy market. High quality standards and good customer relations will be the basis for achieving this goal.

In January of 2009, the LSML has been assessed and found to meet the requirements of ISO 9001:2008 quality standards. The implementation of the ISO 9001 standard was the first step towards a Total Quality Management System. The certificate is valid for the following scope of operation: Production, Supply, Installation, Commissioning, Maintenance of Wind Turbines and Development of Wind Farms. But the management wants more. Their goal is to lead the way towards a Total Quality Management culture and to implement the needed processes.

Implementing a TQM-System is a big step for the company and also time intensive. Also the fact that there are different mentalities in India compared with western countries asks for a different approach. In India we have a so called “management culture”, instead of the “organizational culture” in Europe. The difference between the two mentalities is that the management culture is characterized by the presence of managers in every department. They have the responsibility and the knowledge on the ongoing works. Top management takes all the decisions and lets lower levels only few possibilities to act by themselves. This led over time to anxiety from lower level employees to report mistakes, suggest improvements and take actions. In this different environment, the decision to adopt a TQM philosophy, where everyone should have own responsibilities and be open to suggest improvements means hard work for the organization. But the LSML management has pronounced an ambitious goal; not only a Total Quality Management should be implemented, but they also want to become the first windmill manufacturer to be awarded with the Deming award (see 2.3.3 Quality Awards) what will be the recognition of the performed work.

Together with a consultant, experienced in the implementation of TQM in the Indian environment, the LSML set up a plan (see Appendix A) how to stepwise implement new processes and form the company with continuous improvements over time.

The main objective of this thesis is to gain an overview of the actual status of the different working processes at LSML. Furthermore two processes have to be improved in order to improve the communication and information transfer between LEITWIND Italy and LSML in India.

The practical part of this thesis will be the design of 2 new processes. This will be realized by sticking to the 4-steps-method according to K. Wagner (see chapter 2.3.2.2 TQM philosophy, Process orientation).

The first step is the identification of the different processes at LSML. They will be described briefly and analyzed. The main focus will then be put on the Continuous Improvement and Feedback processes. Their analysis will lead to different suggestions for improvements and to the realization of an improvement plan.

3.1 Main processes of LSML

The main processes are documented in the companies' process manual (Appendix A) that was set up for the ISO 9000 documentation. In the following chapters, the main processes of LSML will be shortly introduced.

They are performed in two different locations: Planning, Production, Purchase, Stores and Distribution, Sales Operation and Maintenance are performed at Gummidipoondi, an industrial area outside of Chennai. Site activities like Installation, Commissioning and Maintenance of Wind Turbines are performed at the different sites, where the manufactured wind turbines are installed.

In this thesis, I want to keep this introduction short, so only a few processes will be discussed more in detail. I will focus on Production, Supply that includes Purchase and Stores, Installation, Operation and Maintenance. These processes can be seen as the core processes at LSML. They are supported by the Finance, the Human Resources and in-house Maintenance department.

Below Figure 3-1 can be seen. A more detailed process map is available in Appendix A.

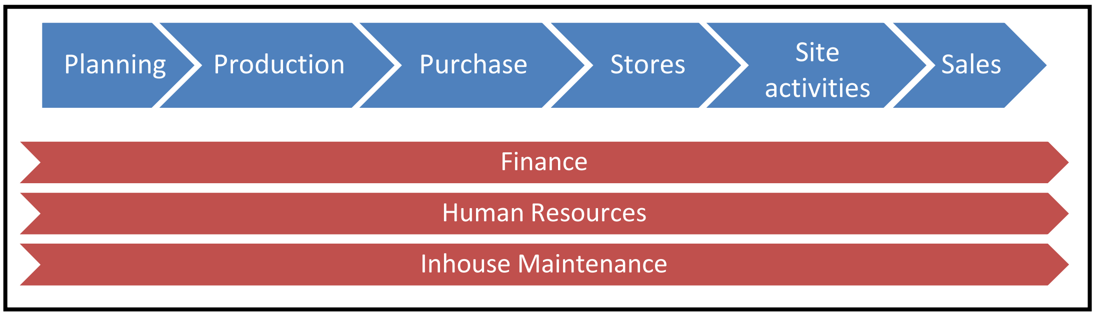


Figure 3-1: Process Map

The most important processes are discussed in the following chapters.

3.1.1 Production

In the machine shop the four main components Rotor, Stator, Hub and Nacelle are machined. The components are delivered to the manufacturing site as welded or as casted blanks. They will then be machined, sand blasted and painted. After machining we come to the assembly stage. The rotor and the stator are combined to the Generator, all electrical installations are installed and the first test runs are performed to check its functionality. Also the assembling of hub and nacelle is performed followed by electrical testing.

For the production process the following interfaces were identified:

- Planning department: is responsible for the planning of the whole production line. They will together with the purchase department assure the availability of the needed material and plan the machine loads.
- Stores: the needed material is delivered by the stores department after the responsible of production has requested them.
- Quality Control: the quality control department checks the machined product before, during and after machining.

Figure 3-2 shows the positioning of the different machines used to perform the different machining operations in the two production halls, building C and D.

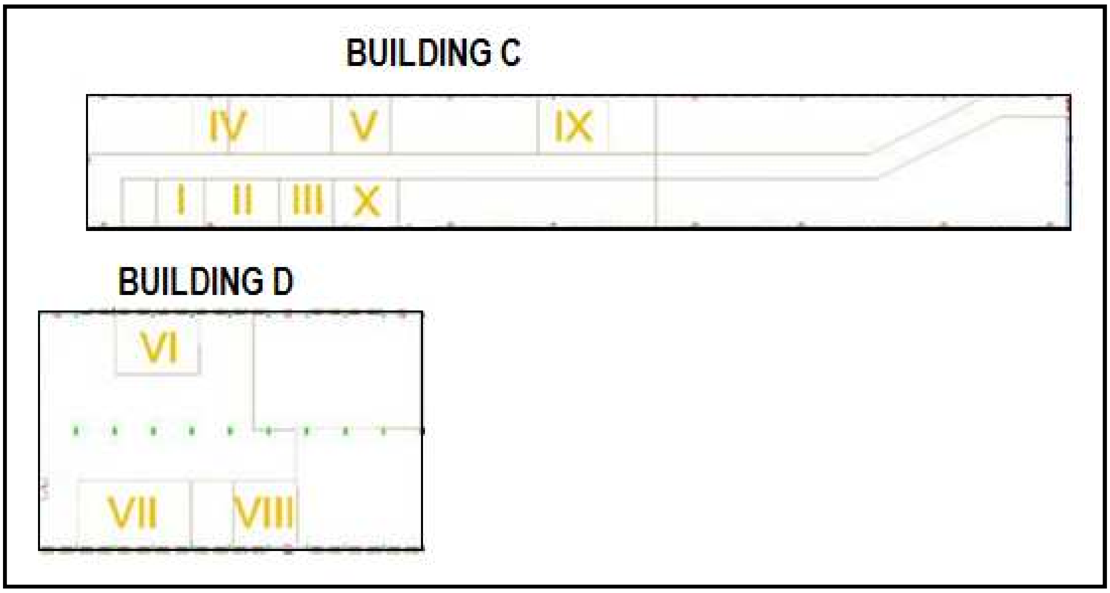


Figure 3-2: production hall

Ten different machines are in use during the machining off the different components:

I. RAFAMAT, vertical turning lathe
II. FRORIEP, vertical turning lathe
III. BATLIBOI, CNC Drilling Center
IV. GATTI TORINO, radial drilling machine
V. SPM, horizontal drilling machine
VI. GEDDINGS & LEWIS, horizontal boring machine
VII. DROOP & REIN, horizontal boring machine
VIII. UDM, universal drilling machine
IX. Little UDM, universal drilling machine
X. CNC, CNC Drilling Center

From now on they will be only named with their number to facilitate the reading of the document. The processes for each component are described in the following pages and show also the development of the manufacturing time over the last year.

3.1.1.1 Machining of the ROTOR

The welded blank of the rotor is delivered to the manufacturing site and has to be machined. During machining it will go through the following steps:

1. Turning operations on the Machine I.
2. The work piece is loaded on Machine III to perform the drilling of the flange holes and the taper holes.
3. For the boreholes, a very long work tool is needed. Due to problems with Machine III, this operation has to be made by the Machine IV.
4. The face drilling operations are performed on Machine VI.
5. Drilling of the sensor holes on Machine VIII, needed for the measuring of the velocity,
6. Grinding and tapping of the tap holes.

3.1.1.2 Machining of the STATOR

The welded blank of the stator is delivered to the manufacturing site and has to be machined. During machining it will go through the following steps:

1. Turning operations on Machine II.
2. The work piece is loaded on Machine III to perform the top face holes.
3. The bearing face and the inside face drilling is performed on Machine IV.
4. The outer diameter drilling operations are performed on Machine VI.
5. The inner diameter drilling is performed on Machine VIII.
6. Grinding and tapping of the tap holes.

3.1.1.3 *Machining of the HUB*

The hub is the only component till now that is sand casted. For the LTW 80 also nacelle, stator and rotor will be casted. The casted blank of the hub is delivered to the manufacturing site and has to be machined. During machining it will go through the following steps:

1. the cast has to be sandblasted first and then covered with the first layer of painting
2. The face drilling operations of the flange holes are performed on Machine VII.

3. Universal drilling and tapping are performed on Machine VIII and manually.

3.1.1.4 Machining of the NACELLE

The welded blank of the nacelle is delivered to the manufacturing site and has to be machined. During machining it will go through the following steps:

1. the welded blank has to be sandblasted first and then covered with the first layer of painting
2. The face drilling operations of the flange holes are performed on Machine VI
3. Threaded boring is performed on Machine VIII.
4. Grinding and tapping of the tap holes.

3.1.1.5 ***Assembly***

- Active parts:

The active parts are the heart and soul not only of the generator but also of the whole machine. They are responsible for the electricity production in the working machine.

The assembling of the active parts contains the following steps:

1. stator stacking
2. coil winding
3. coil insertion into the stator stack to get a stator segment
4. impregnation of the segments
5. assembling of the permanent magnets

-Generator, Nacelle and Hub:

After machining and painting, the main components will be assembled in the manufacturing site. The hub and the nacelle will be assembled separately with his components such as: bearings, electro motors and brakes. The rotor and the stator are putted together with the active parts to become the generator.

At the end of the assembling we have our four separate components, hub, nacelle and generator ready to be shipped all over the world.

3.1.2 Supply

The purchase is in charge of providing all the materials and components needed by the production and the assembling in the right place at the right time in the right quantity and in the right quality.

Considering the time factor during purchase we will have approximately the following situation: the average number of manufactured windmills per month is four, due to the actual manufacturing plan. The material consumption speed can therefore be seen as constant. The variable in purchase is the lead time of the supplier and therefore the ordering moment. According to Figure 3-3, the purchase orders are made when stock reaches a certain signal stock. The amount of the purchased materials depends on the manufacturing plan, the actual stock and lead time of the supplier. One of the big challenges is the problem that the purchase department is dealing with long lead times up to six months. This requires good communication between the purchase and the planning department, because material that is not ordered today could not be available after six months.

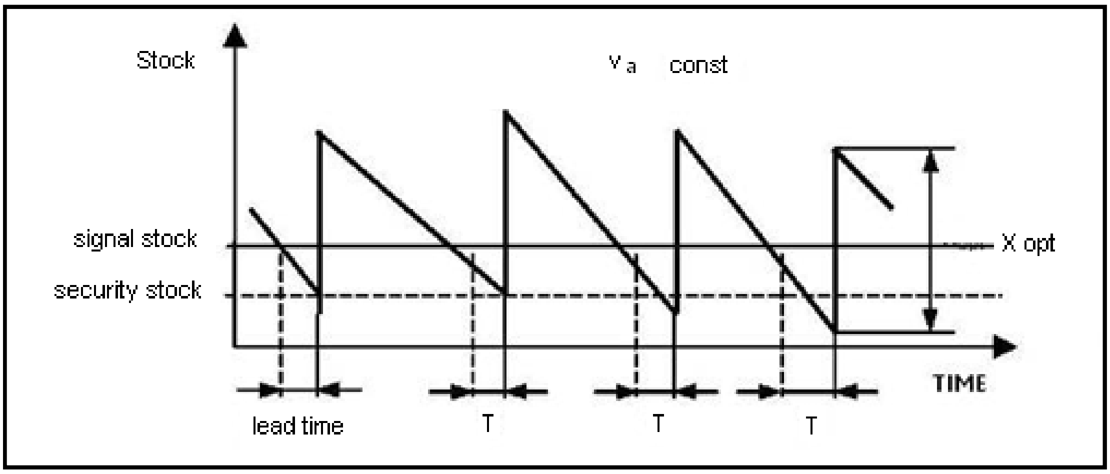


Figure 3-3: Stock over time[71]

The purchase structures the imported goods in different groups:

- Steel: The whole steel needed by the subcontractors to fabricate the rotor, stator and the nacelle is bought by the LSML. After being delivered to the site in Gummidipoondi, it will be stored, its quality will be checked, the plates will be cut in the needed dimension and then it will be sent to the different subcontractors. After fabrication, the raw

[71] WOHINZ, J.W.: Induscript Industriebetriebslehre, Graz 2008/2009, XXII, p. 33 chapter 5.

component will then be resent back to LSML where it is then machined.

- Forgings: The forgings are machined by the LSML and the sent to the subcontractors for fabrication.
- Fasteners: Fasteners are needed for the assembling of the different components.
- Bought out components: The bought out components include bearings, e-motors, brakes and other components not manufactured or assembled at the LSML.
- Subcontractor components: These are components fabricated by subcontractors where the LSML did not provide them with raw material.

The supplier brings the incoming goods always with a so called delivery challan. The storekeeper then will check the content and compares it with the purchase order. After that, he will check for damages and document them if necessary with photos. The ware is then unloaded.

Through Movex, a Goods Receipt Note (GRN) is being generated, and the goods will be handed over to quality inspection. The quality department then has to approve the adequate quality and gives the ratification to update the stock quantity in the system by signing the GRN. If the material does not meet the required quality, the cause for the non-acceptance is documented, the material is putted in the rejection area and the purchase department informs the supplier.

If the material is accepted stock is updated into Movex and separately in excel. Excel is needed to attach additional information to each product, such as stock area where it is situated (in future it will not be needed anymore due to implementation in SAP). After the GRN acceptance, the material will be handed over to the stocking area.

When the material is needed, the production planning department generates a manufacturing order, which gives the needed information to the stock department. The material will then be delivered to the assembling area. Again, after confirmation of the assembling, stock is updated, and the item status changes from stock to assembling.

The material management divides the LSML in three different groups according to the location. Furthermore the stored materials can be allocated to the different storage areas, which are mapped in SAP.

The material requirement goes through different process steps:

A material requirement plan is created with the production plan. The required amount is then compared with the stock amount. If there is not enough stock, a purchase requirement is created. The purchase department creates a Purchase order with the different terms and conditions of the supplier. After the supply of the ordered goods a Goods Receipt Note is created, with its ratification, the material is added to the stock.

Following interfaces were identified:

- Planning department: is responsible for the planning of the whole production line. They will give the order for purchase to supply the production with materials.
- Machine Shop: the needed material is requested by the machine shop responsible when needed and is then delivered to the needed place.
- Quality Control: the quality control department checks the incoming goods before adding them to the inventory. Rejected goods will not be added to stock and will return immediately to the supplier. The amount of non-conform materials supplied at the factory is high. This means that the quality control has to be performed really well to ensure that only high quality materials are used in production.

Figure 3-4 shows the percentage of rejected items supplied by all suppliers at the factory in the last 16 months.

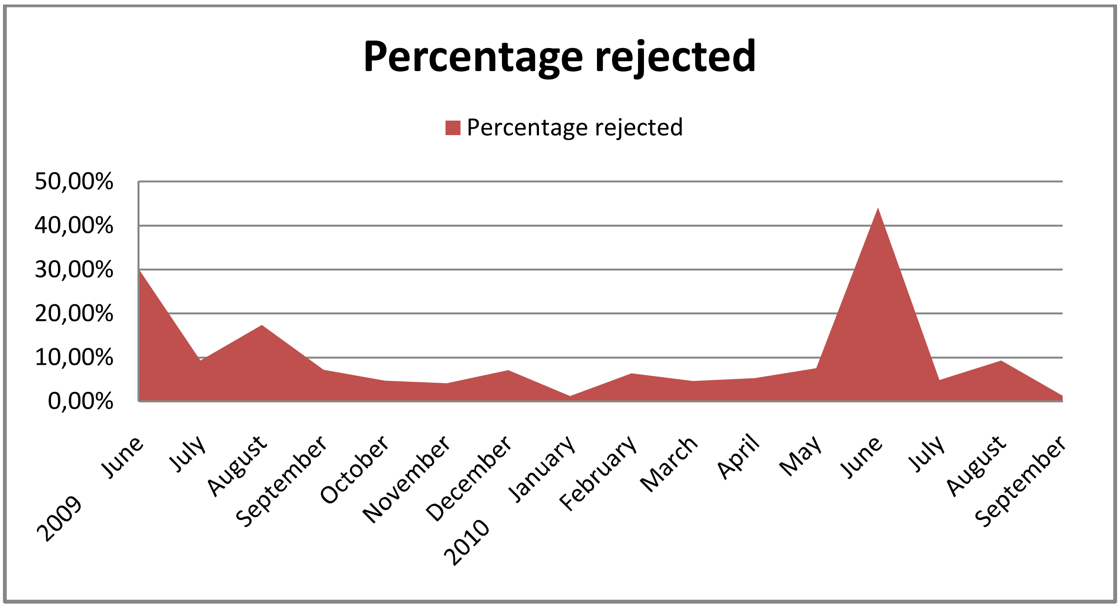


Figure 3-4: Percentage of rejected items per month

The percentage of rejected items over the last 16 months amounts to 6, 83%.

3.1.3 Installation

The installation is performed in 3 main steps by the three different teams: infrastructure, installation and commissioning. After this the wind turbine is ready and fully operational and can be passed to the maintenance department that will monitor it during the operation.

The infrastructure department is responsible to find and prepare the land on which the windmill will be installed. Estimation on future electricity production has to be done in order to calculate the return on investment for the customer. After the decision on which land to buy, further organizational measures have to be done until the land is ready to install the wind turbine and it can be requested from the production site.

1. first step is to collect wind data of the desired area in order to predict the electricity production of the turbine in the specific location
2. after the decision of the location, the land has to be bought. It is either bought by the customer or by LSML
3. the state energy board has to be contacted in order to get the permission to connect the machine to the grid

4. at this point the machines can be requested from the factory for installation

During installation the wind turbine is erected and it is connected to the grid. Before the turbine reaches the location where it will be build, the foundation and all the needed construction work is performed.

1. the foundation and the building for the control room are build
2. main components like Tower, Nacelle, Generator, Hub, Blades and the electrical installation are then installed. It takes about three to four days.
3. the electrical connection between control room and grid is performed

After the installation is finished the turbine has to be commissioned. During commissioning first tests are done on the machine, during this the safety certificate for the installation has to be obtained by the government. The machine runs for the first two months under surveillance of the commissioning team, after that it can be handed over to the maintenance team that will be responsible for it during the next ten months. This is the period where the initial warranty is valid. After the first year of operation the machine is not under warranty anymore.

Following interfaces were identified:

- Marketing department: the marketing department will give the order where different wind data should be retrieved and where the new windmills are planned.
- Planning department: In order to time production, dispatch and the finished work at the site.

3.1.4 Operation and Maintenance of the Wind turbines

The LSML is also taking care of the operation and maintenance of installed wind turbines. This is performed by the Central Monitoring Station and different service teams. For this the running machines are monitored continuously by the CMS that observe the power generation of each machine and its proper functioning. The CMS in India performs the monitoring for worldwide installed machines by LEITWIND.

At the same time service team personnel is present at each wind park permanently. They are responsible for maintenance and service operations on the turbine. Should any error occur on any machine, it will alarm both the

CMS and the service team. Some error can be reset through the remote control system of each machine. But if an interaction on the machine is required a service team has to be sent for inspection. All needed materials during maintenance and service are managed by the CMS.

In addition the CMS is responsible of all the reporting regarding the running machines like generation reports and error log. They collect the service reports from the service teams after taken actions and use this data to perform failure analysis together with the trouble shooting department in Italy.

Following interfaces were identified:

- Purchase department: materials needed on each site have to be requested from the purchase department
- Stores: stock of maintenance material is available at the factory and sent to the site when needed
- Trouble shooting department Italy: Reports on occurred failures and taken actions are sent to Italy in order to perform failure analysis of the running machines.

Résumé: After the identification of the different processes some improvements can be identified and suggested. The overall situation is as follows: the production constantly increased over the first two years. Also different modifications to the products itself were made permanently. This caused several variations to the production process and to the manufacturing time. Also the analysis of possible improvements was much more difficult due to this. But production is now coming to a regular pace and this will make it possible to make observations how the processes can be improved under higher pressure. One possible improvement would be to determine and create more detailed machining routes. This means that the incoming raw material has their standardized and planned way through the production line. This includes intermediate storage places between different manufacturing stages and buffer places. This will ensure that there will be no interference in future production scenarios.

The different storage locations have to be improved. Again, also here it was difficult to adapt the storage to the constantly increasing incoming goods. Organized and defined storing locations have to be planned in order to support better the manufacturing and assembly procedures. For this also the distance between the storage place and the place where it is used has to be kept as short as possible.

The next improvement would be to improve the communication processes between India and Italy. As already described, the R&D, the technical and the Product Care department are situated in Italy and so far away from the manufacturing site. The technology know how has to be transferred to India were the designed products are produced. This makes the good functioning of the communication processes vital. This is why the processes dealing with continuous improvements and the feedback process are analyzed and described more in detail in the next chapters. The design and implementation measures of the improvements will be the outcome of this thesis.

3.2 Continuous Improvement Process (CIP)

The good functioning of a continuous improvement process is the driving force for a strong future development of the company. Because the technical department is situated in Italy and the production of the windmills is situated in India, it is of big interest to set up a communication channel that transmits ideas and suggestions from production to the technical department and connects the two continuous improvement processes.

The goal is to define a process according to Leitner-Standards, which describes the information flow of continuous improvements between LSML India and LEITWIND Italy.

Needed process steps and key figures have to be defined in order to make an implementation of the process possible.

3.2.1 Process identification and delineation

The standard procedure for the exchange of information, modification requests and new ideas between the technical department of LSML and LEITWIND has to be improved in order to create greater transparency on the ongoing works and on the status of the different requested modifications. Occurring problems that are discovered during manufacturing because of erroneous drawings or failures in the design of the product have to be documented. Also later during the assembling process nonconformities can be detected. These problems have to be transferred to the technical department. This will ensure that corrective actions are initiated and that the manufacturing drawings are revised for future production.

Purpose of the process is to structure and document the information flow of continuous improvements between the LSML and LEITWIND. The internal customer is the continuous improvement process at LEITWIND and its expectations from the outcome are to gain new experiences from LSML that arise during production and suggestions for improvements regarding the product.

From the input that can be a thought of improvement, an idea or a suggestion by an employee in India, the output should be the implementation of the improvement. The process will start with the submission of a proposal that can come from any employee from the different departments. The suggestion will then go through the process in order to deliver implementation steps for the improvement. The head of the regarding department will be the one assigned with the implementation. In order to evaluate the performance of the improvement, the process will be observed and evaluated.

For the improvement of the continuous improvement process the creation of two new positions are necessary, the Continuous-Improvement-Process-Person (CIP-P) and the Kontinuierlicher-Verbesserungs-Prozess-Person (KVP-P). KVP is the denomination for CIP in german. . The different denomination was chosen to distinguish them from each other. They are responsible for the continuous improvement process, the CIP-P for the Indian process and the KVP-P for the Italian

For a successful implementation and development of the process the involvement of the whole staff is required in order to deliver quick and accurate feedback to given suggestions. To ensure good results the information loop has to be closed in order to assure fast implementation of new ideas and constant feedback on the efficiency of improvements.

3.2.2 Analysis of the actual Continuous Improvement Process

In order to gain an overview on the actual situation, the way how the LSML exchanges information with LEITWIND was observed and described in Figure 3-5: actual CI-Process.

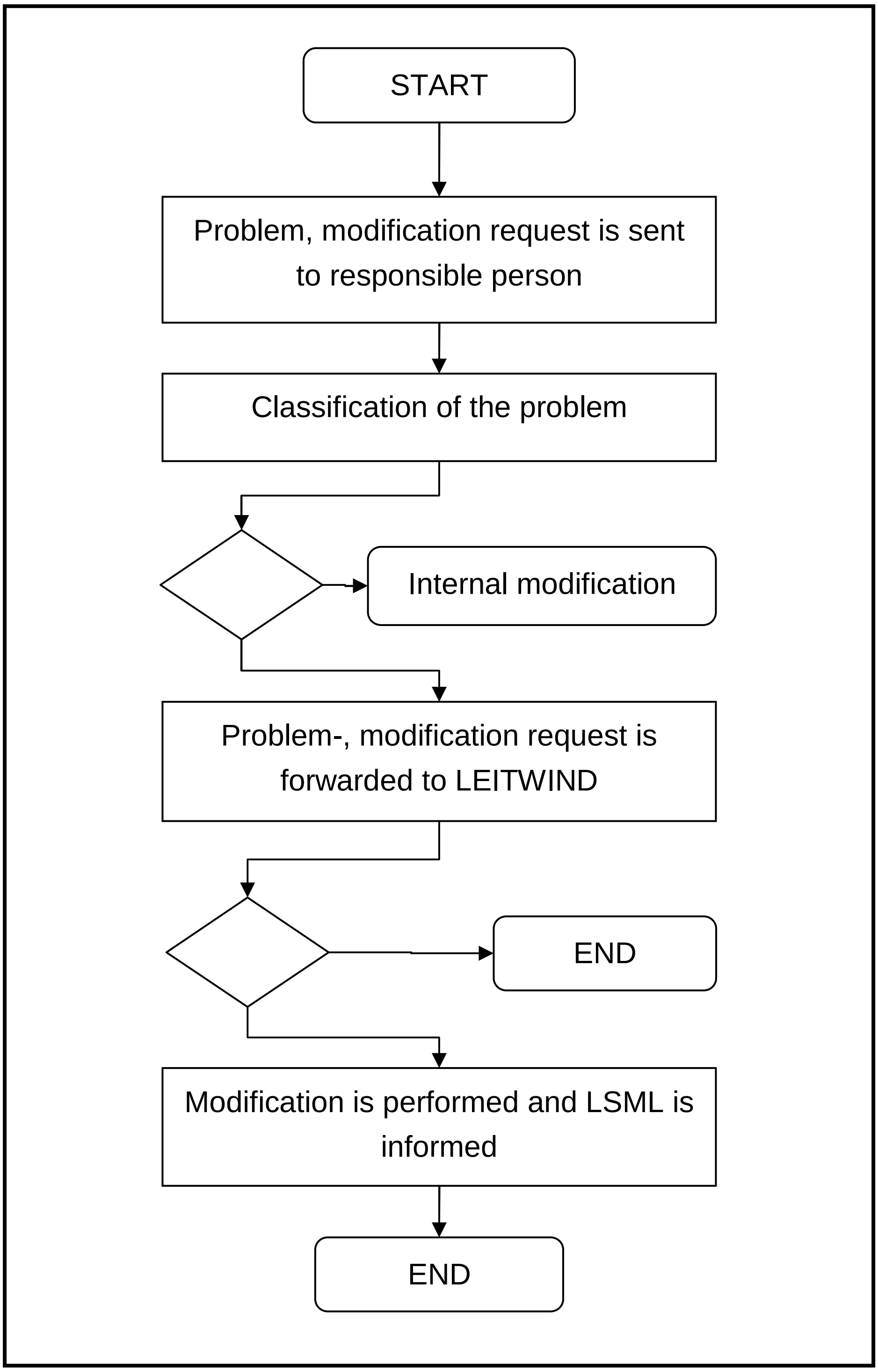


Figure 3-5: actual CI-Process

When facing a problem during production or assembly where a modification is needed in India, the supervisor sends a modification request to the technical department. A special form that was implemented in the past should be used to transfer the information regarding the problem. Until now it is not yet used by every department. Problems are then transferred through email or by phone.

The technical department classifies the problem and decides whether it is possible to make a temporary adaption or if the problem has to be forwarded to LEITWIND Italy for modification. This decision is taken by the head of the technical department at LSML. The LEITWIND technical department: checks feasibility of request and answers to the modification request with comments and if required with the needed drawings.

The actual process cannot be seen yet as a continuous improvement process, but more as a modification request process. The different departments: machine shop, quality, purchase, assembly and technical department are facing different problems during production and assembly. This problems need to be solved in order to continue with the production. But also for future product releases these problems have to be removed already in the planning phase. The main information exchange between the two departments is related to the following topics:

- Modification requests
- Ratification of drawings
- Synchronization of LSML database
- Re-design of products
- Updates of specifications and regulations

The communication between the different departments and between Italy and India is mainly performed via email. Communication regarding a certain problem or idea cannot be tracked or seen by anyone else. Information is only stored in everyone’s emails.

The information about all the changes on the drawings that are necessary for the manufacturing or assembly have to reach the technical department in Italy. This information flow has to be improved in order to speed up the processing time from occurring problems to implementation of the solutions. Furthermore the increase in production will demand for a fast and smooth execution of modifications and the rising of improvements will help optimize the product. The traceability of modifications and improvements to the product that will be available with enhanced documentation will make it possible to set up a product history. Development of the product can then be monitored at any time and the reason for past changes can be displayed.

Figure 3-6 shows figuratively the observed actual status of the used communication media and the information flow between the LSML and LEITWIND. A standard communication media has to be implemented in order to secure better traceability and documentation.

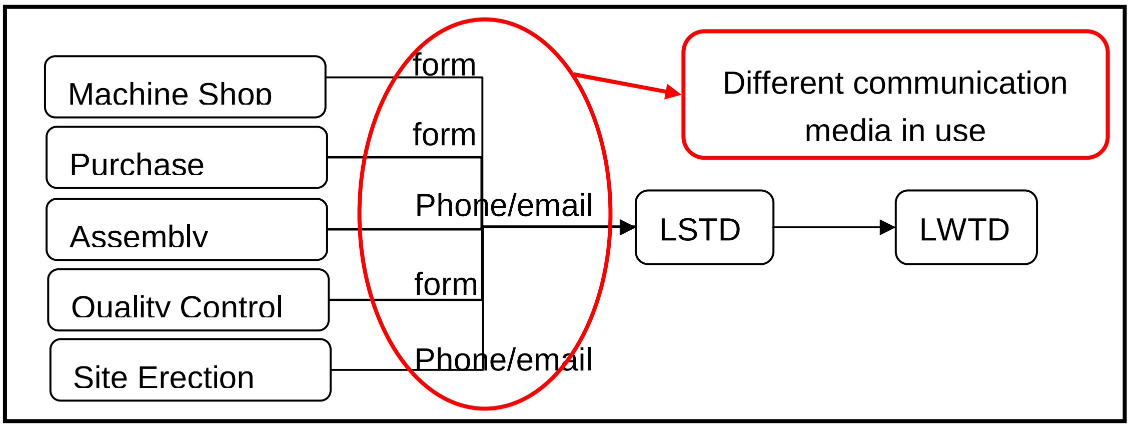


Figure 3-6: Communication media

Figure 3-7 shows figuratively the observed actual status of the information flow between the LSML and LEITWIND. Modification requests are sent from the submitter to the responsible person in Italy directly. A standard communication channel that will channel all information will help keep the overview on the ongoing requested works. Also one person would be in charge of the whole communication alone and therefore save a lot of work to all the other people in the company.

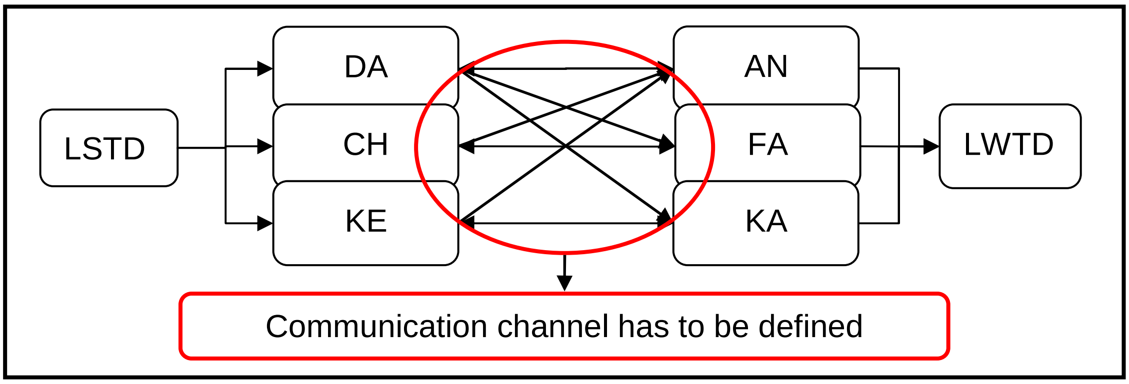


Figure 3-7: Information flow

After analyzing the actual process, the problems that were noticed had to be solved in order to bring in new improvements to the CIP.

Due to the absence of a standardized communication channel, the communication regarding the different requests, improvements and nonconformities is performed by various people. This leads to a decrease of the overview on the actual requests. For this a single communication channel should be established managed by a single person. His function will be to survey the exchange of requests, data and information and to check the actual status of each request. This will also solve the next problem of traceability. Due to the fact that all the modification requests and improvement proposals are channeled through the single communication channel, the regarding documents can be found in one defined place, plus the documentation of the process can be performed parallel.

As of now, feedback on the estimated execution time of a modification by the technical department in Italy is not given. LSML would like to have this information in order to plan their procedures according to the estimated completion times given by LEITWIND. Furthermore this first feedback is also a signal that the work has been accepted and is under process. This saves unnecessary requests by LSML on the status of the modification.

The way of reporting has to be standardized. Two documents have to be implemented in order to help the communication. One form is used for modification requests and nonconformities. It needs more detailed information and due to this it will only be used by the technical department in India. The second document is the improvement proposal form. It is a more simple form intended for the employees in the different departments. This document can be used to by everyone to express own improvement proposals.

The administration of the CIP cannot be done by the different heads of department, because it would mean additional work for them. The CIP-P would take over the organizational problem by preparing the requests in such a way, that the responsible only gets the requested modification or improvement proposal that he has to work on.

3.2.3 Conceptual design of the Continuous Improvement process

Based on the analyzed problems, the process has to be improved to ensure a better and more efficient communication and knowledge transfer.

The main focus will be held on the improvement of the following points:

- Define a single communication channel. All the information exchange between India and Italy has to pass through it. The documentation of the process has to be ensured by the responsible person.
- Ensure a good feedback, so that the motivation to submit good and new improvement proposals remains high.
- Standardize the way how the problems and proposals should be communicated. Therefore a standardized process will be set up and implemented at the factory.

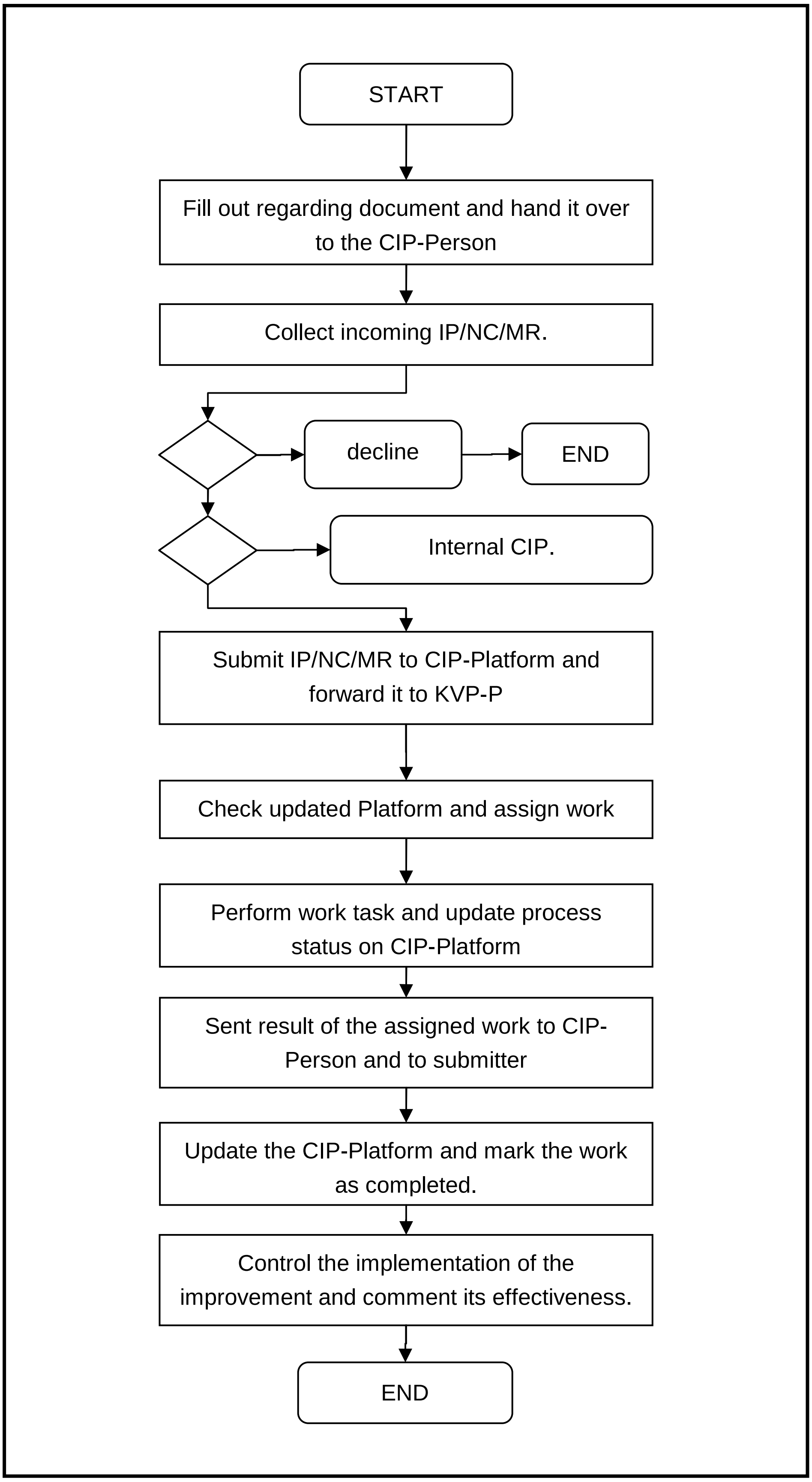


Figure 3-8: process flow of the designed CI-Process

Figure 3-8: process flow of the designed CI-Process shows the different steps of the improved continuous improvement process. The first process step is the submission of an:

- Improvement Proposal
- Modification request
- Nonconformity
- Drawing ratification
- Drawing, specification update

The required document has to be filled out and handed over or sent to the CIP-Person. The CIP-Person is the central person of the Continuous Improvement Process at LSML and is responsible for it.

He has to collect all the forms containing Improvement Proposals (IP)/NonConformities (NC)/Modification Requests (MR) and periodically hand it over to the Destination Department Responsible LSML (DDR LSML) for the feasibility check. The DDR LSML decides what further steps to take regarding the suggestion and decides if it has to be forwarded to LEITWIND or if it can be performed internally. Rejected IP/NC/MR have to be documented as well and the submitter has to be informed about the reason.

The IP/NC/MR that will be forwarded to LEITWIND are introduced into the CIP-Platform and saved under the regarding folder. The CIP-Platform is the organizational chart that will be used to display all the ongoing works and help manage them. It will be explained more detailed later on in this chapter. The CIP-Person will then only inform the KVP-Person that the CIP-Platform has been updated. The KVP-P is the person with the same responsibilities and tasks as the CIP-P for LEITWIND in Italy. The new IP/NC/MR. will appear on CIP-Platform. The KVP-P then has to assign it to the Destination Department Responsible LEITWIND (DDR LW). Each department Head will then assign the work to the responsible person.

The responsible person becomes the assignment to perform a work. At first he has to give first feedback with the estimated completion date. Then he has to keep the platform updated in order that the KVP-P and the CIP-P have an overview on the ongoing works. When completed the finished work has to return to the CIP-Person and to the submitter. Only by this, clear documentation of the process is ensured and a clear communication channel established.

In order to check if the improvement was implemented properly, the CIP -P will check on the implementation status and evaluate the new process 3 months after implementation.

During the Continuous Improvement Process between LEITWIND and LSML three different ways of communication procedures are performed:

- **From submitter to responsible person:** The information flow is channeled through the CIP communication channel. This will ensure a clear and secure way to get the request or problem on the CIP-Platform and to the responsible person.
- **Communication during problem solution:** the communication channel can be left. The responsible person contacts the submitter directly for clarification of emerged problems to avoid misunderstandings.
- **Finished Work:** to ensure that the results can reach the submitter in the most direct way, the responsible person has to send the results with the regarding data to the submitter. This email has also to be sent back to the CIP-Person, so that the status of the work can be updated on the CIP-Platform and the right documentation of the process is possible.

Both the CIP-P and the KVP-P will have to manage all the ongoing works and assign them to the responsible persons. To facilitate this process a CIP-Platform will be set up (seeTable 2: Continuous Improvement Platform).

CIP-Platform										
Part to be filled out by submitter						Part to be filled out by recipient				
Problem no.	Date	Suggestion	Submitter	Category	WTC type	Response Date	Assigned to	Planned Execution	Work description	status
LS056	03.07.2010	New flange for nacelle……	Peter	Mod. Req.	LTW 80	14.10.2010	AN	13.07.2010	Holes will be inserted in new drawing	in progress

Table 2: Continuous Improvement Platform

Only the CIP-P and the KVP-P will have the right to make changes to the platform, all other people involved in the process will have only the authorization to read the document in order to check the status of their request or proposal.

Regarding documents like pictures, drawings, forms and further information will be saved on a shared folder "CIP". Both LEITWIND and LSML will have access to it. For every new IP/NC/MR a new folder is created with the serial number. After checking the CIP-Platform the more detailed information can be looked up in the regarding folder.

In order to monitor the process, key figures have to be created to give a good overview of the process status and its development. The key figures should be self explaining. Ideally no additional work has to be done to get them.

The key figures will give information on:

- Quantity:
  - Total number of proposals
  - Number of proposals of the following year
  - Number of proposals of each month
- Efficiency:
  - Proposal/employee figure
- Effectiveness:
  - Last submitted proposal
  - Percentage of proposals answered in a given time frame
- Status:
  - Number of works without answer
  - Number of works in progress

For every process member a process task-card (see Figure 3-9) describes the inputs, outputs, interfaces and tasks. This should help understand better the own role in the process, define the exact tasks and help during implementation.

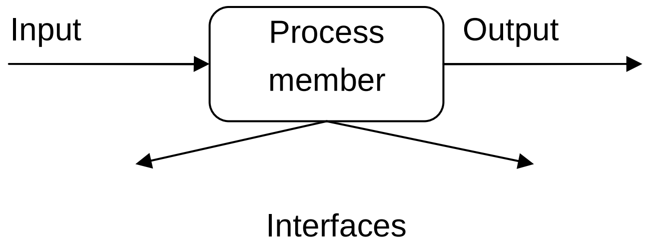
<table>
<tr><td>Process member:</td><td colspan="2">Process member Denomination</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td>Interfaces:</td><td colspan="2">➢ listing of the interfaces
➢ which departments has to be interacted</td></tr>
<tr><td>Input:</td><td>Process tasks:</td><td>Output:</td></tr>
<tr><td>Listing of the inputs regarding the process.</td><td>Description of all the tasks that have to be performed by the process member</td><td>Listing of the outputs regarding the process.</td></tr>
</table>

Figure 3-9: Process Member Card

Process cards of the different process members are attached in Appendix B.

The process will be the connection between the two Continuous Improvement Processes in Italy and India. It will ensure a good and clear information flow in order to close the information loop between the technical department LEITWIND and the production of LSML. This will help not only resolve occurring problems but should improve the product in order to prevent errors in future.

Figure 3-10 shows the simplified process map of the CIP. In Appendix B the more detailed process flow is displayed.

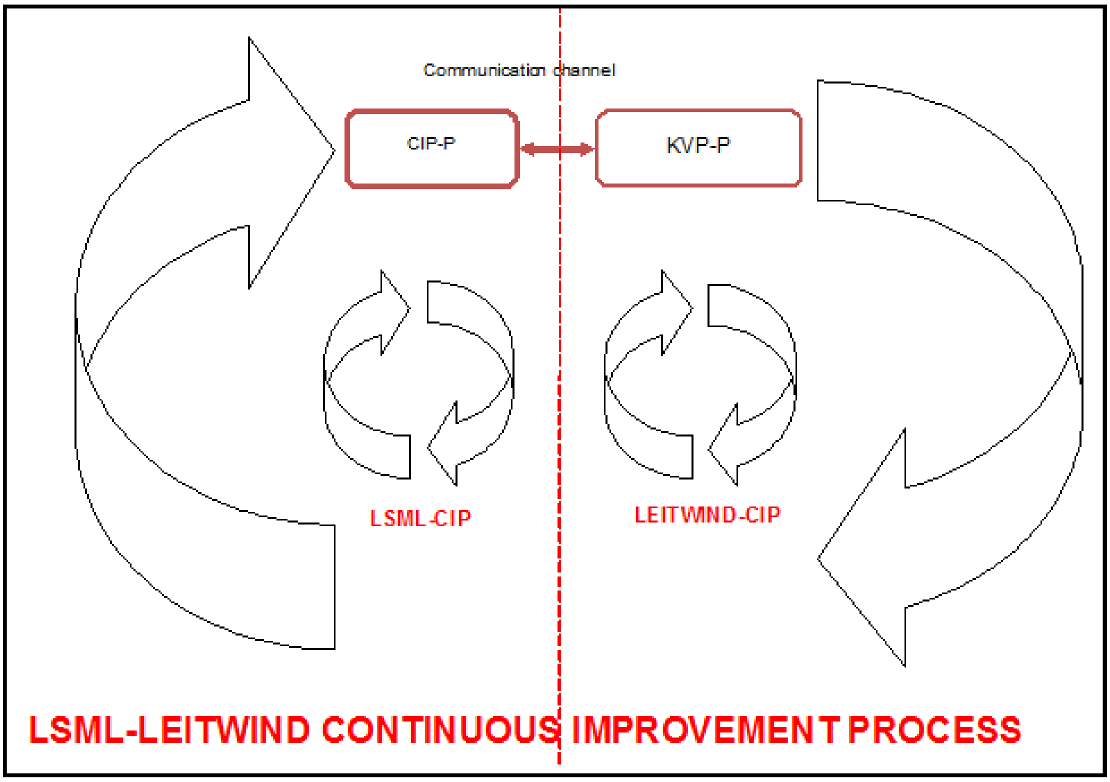


Figure 3-10: LSML-LEITWIND Continuous Improvement Process

3.2.4 Realization of the improvement

With the realization of the improvements to the actual process the company is expecting the some advantages. The overview of the requests from LSML to LEITWIND will be enhanced due to the CIP-Platform. It will be possible to monitor the whole process and always have the overview on all the submitted IP/NC/MR works that were submitted. This will prevent requests from being forgotten or overlooked.

The efficiency of the communication process, that determines also the reaction time of the company to occurring problems, can be monitored and therefore also analyzed in order to detect further improvements. The responsible of the process can easily drive the process into the direction he wants.

The integration of LSML improvement proposals into LEITWIND suggestion system will bring further ideas and suggestions coming from production and assembly that can help improve the actual products and the development of new products.

For the right implementation of the Continuous Improvement Process a plan has to be prepared. The implementation will run over three phases:

- “Dry run”: discussion with all involved people to detect failures and weaknesses of the system before the actual start.
- 1st Phase: test run over a delimited period and delimited department Variations and new ideas should be documented and discussed in order to implement them in the new process.
- 2nd Phase: Actual stepwise implementation of the process in daily business. Process has to be followed by responsible person.

Two new positions inside the company are created with the implementation of the process: the CIP- and the KVP-Person position. There will actually be no additional work, because organizational work will only be shifted from the head of the different department to the CIP-Person and KVP-Person.

1st Phase of the implementation will take 2 months in order that the involved people get familiar with the new process. The KVP-Process at LEITWIND also has to adopt some changes during this period.

Steps for the 1st implementation-phase of the CIP at LSML: During the first implementation stage of the CIP at LSML, a person of the technical department has to be chosen to take over the responsibility of the process. After having set up a CIP-P email account, the mechanical department will be the first department where the CIP is implemented. The new Improvement Proposal Form has also to be introduced, before the CIP responsible can start with the first request. When this is completed, the first proposal and requests can be introduced into the CIP-Platform. This testing stage is followed by the second implementation stage.

Steps for the 1st implementation-phase of the CIP at LEITWIND: At LEITWIND, there is not a KVP-Person that is responsible for the process yet, therefore anyone can take care of the incoming requests from the CIP-Person in the first stage, whereas there will only be requests from the mechanical department from LSML at the beginning. The KVP-P email account has to be set up, and assigned to the responsible person. After the first request through the CIP-Person will come to KVP-P, it has to be forwarded to the responsible person who is in charge of the problem. A copy of the finished work has to be sent back to CIP-P, so that it can be kept track of the finished works. Weekly, the Platform is to be sent to the KVP-Person for a short status update regarding the requests. The testing phase is followed by the second implementation stage.

The second stage of the CIP will slowly introduce the different departments of both, LEITWIND and LSML, until the whole company is connected.

Steps for the 2nd implementation-phase of the CIP at LSML: During the second implementation, a CIP-Board has to be set up, in order to evaluate future improvement proposals coming from the different departments. As soon as the shared server is available, it has to be configured and used to share the data between the different departments. Starting from the electrical department, the process will be implemented in all the remaining departments. The CIP-Person will be responsible to take the needed actions. In order to measure the improvement, and to check the right implementation, an evaluation of the implemented proposals has to be done every three months. This evaluation will close the information loop by evaluation the efficiency of implemented processes.

3.3 Feedback-Process-System/ Non-Conformity-Process

At the moment service reports regarding maintenance and repair activities are only available on demand. They are not available through the system.

Although an up to date information platform, with all the information on the different troubles on the different wind turbines combined with taken action to resolve the problems would be of great help feeding the failure analysis department in Italy with data.

The goal of the implementation of this process would be to:

- define a Feedback-Process that connects the 2 Failure analysis-Processes of India and Sterzing.
- create a platform where the essential information can be seen. A classification of the different problems has to be done according to Leitner standard classifications.
- Useful software could be implemented as well afterwards.

The Feedback-process will improve the information on the occurring problems in India.

3.3.1 Process identification and delineation

As of now the trouble shooting department in Italy tries to solve different problems that arise on installed machines. They have access to all the data recorded from the machines worldwide through monitoring software.

To improve the failure analysis, the information on what exactly caused different problems on the machines and what taken actions helped resolve the problem would be very helpful. And exactly this information is not available in an updated form from the Indian machines. The department responsible for the service teams in India is the Indian Central Monitoring Station. It is in charge to monitor the data of all the installed machines and also to collect the different service reports from the Indian service teams. Until now they used to send monthly a summary of all the broken and replaced items on the machines to the trouble shooting department in Italy. This process needs to be improved in order to get more detailed and useful information from the CMS in future.

Purpose of the process is to ensure the transfer of information about site activities in India to the trouble shooting department in Italy. This gained data will be needed for failure analysis. The internal customer is the trouble shooting department at LEITWIND and its expectations from the outcome are to gain new clear up to date data from the CMS. Since the information on taken actions by the service teams in Europe are all recorded, the information from the Indian part would add up data for analysis.

The input into the process are error descriptions and detailed information regarding the taken actions to resolve errors on the Indian machines. The output is a weekly updated platform containing exactly the information on the taken actions and services on the installed machines. The process will start with the reporting of an error occurred on a machine to the Maintenance and operation team and ends with the submission of the new gained data into the Feedback platform that will be sent to the trouble shooting department in Italy.

For the execution of this task, no extra know how is needed. The report that has to be prepared links two already available reports, they only have to be fed into the new Feedback report.

3.3.2 Analysis of the actual Feedback Process

The actual process from error detection until error correction on installed wind turbines was analyzed. It is as shown in Figure 3-11:

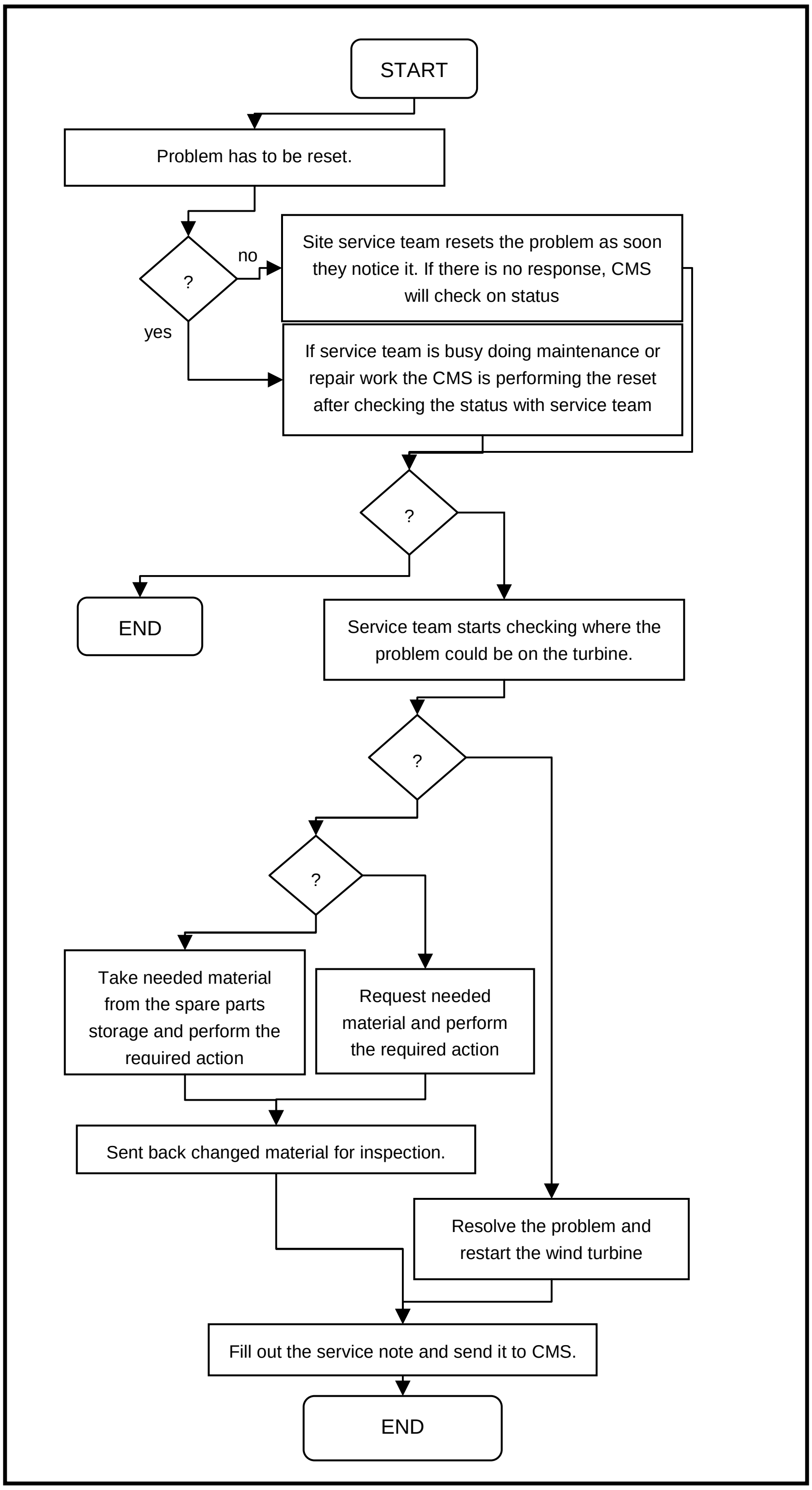


Figure 3-11: actual Feedback Process

The monitoring system of the running turbines signals an error due to specific parameters and makes the turbine come to a full stop. It is important that the problem causing the error is found as soon as possible so that the turbine can start operating again. For this the CMS is monitoring the world wide installed machines. As of now, the CMS performs two different procedures: one when dealing with problems on international machines and one when dealing with the Indian machines.

The procedure for the international machines is as follows: the CMS detects the error. The different parameters have to be checked according to the Control System Manual from LEITWIND in order to detect some abnormal value. If not the system of the machine can be reset and the machine can operate again. If after resetting the problem is still occurring and there is the need for an intervention on the machine, the Hotline in Italy is informed, who will then send a service team to resolve the problem.

The procedure for the Indian machines is as follows: both the CMS and the different Service teams that are located at each site are monitoring the machines. After an error signal turns on, the cause has to be investigated and the problem solved as soon as possible. Whereas on international machines it is clear that the CMS performs the first reset on the machine, here both the CMS and the service team are doing it. The CMS observes if the error is solved, if not they will get in contact with the service team to know what is happening. Also it is not possible for the CMS to reset the machines without contacting the service team because they don’t have the information if somebody is working at a machine at that time, because it is not yet possible for the service teams to put the machine on crew present. If after either the CMS or the service team tried to reset the turbine and the problem can still not be solved, the service team goes on the turbine for an inspection.

The CMS should always be informed about what is happening on each turbine. If there has been some damage to the machine and new material is required, the service team uses the spare parts that are available at the site storage or requests the needed material from the CMS. The CMS is in charge of handling all the needed material during service.

When the taken action is over the machine is restarted again and the detailed information on the performed work is documented on the service note (document QM/F03/A) and sent to the CMS. This data is needed for failure analysis.

One of the biggest problems nowadays is that the service reports are not sent to the CMS in time. As now (2.12.2010) the service notes are still missing from the 10th of August. The focus is not put on the information flow from site to CMS. A lot of reports are done by the CMS containing huge amount of data like data on daily generation, availability and upcoming errors. But still the most important data, containing the information on how the problems were resolved and what was the cause of the problems, is missing. This information has to reach the failure analysis team and so the design team to improve the product in future.

Some tasks are not clearly defined by whom they should be performed. Therefore time is spent by both the CMS and the service teams to perform the same action, like the monitoring of the operating turbines: in the CMS as at the site a team of people is working 24/7. Both are monitoring the machines and trying to solve occurring problems. It would be better to decide which team is responsible of monitoring and reset the machines. For a better overview of the procedures and taken actions the CMS should perform it, and go through the same procedure as for the international machines. If the error cannot be solved through pc they inform the service team and send them to the specific machine for inspection. At the moment where the service team is on the turbine, the turbine should be blocked and the service team in charge of it until the problem is solved. After the restarting of the turbine the CMS has to be informed and a service report has to be sent to the CMS for documentation and failure analysis.

As the CMS has no overview on ongoing works on the different machines, they also do not know if the service team is working on certain machines or not. This is also because it is not yet possible for every service team member to block the machine correctly but only by triggering the emergency stop button. This leads to different errors where the CMS does not know if they are caused by the machine or by the service people performing some work. By reorganizing the procedure steps between CMS and the service teams the CMS will always have the overview on ongoing works on every machine. This would make the most sense, as they are responsible for the monitoring of the machines, the organization of the spare parts on the site and for the failure analysis.

3.3.3 Conceptual design of the Feedback process

Based on the analyzed problems, the improvements to the process have to be designed to ensure a better and more efficient communication.

The main focus will be held on the following points:

- Assign the monitoring of the operating machines to one department only in order to get a better overview on the ongoing works
- Make sure that the service team gets already additional information on the occurring error before they depart for the service inspection
- The service team has to fill out the service report in an accurate way and submit it within 10 days after the performed service

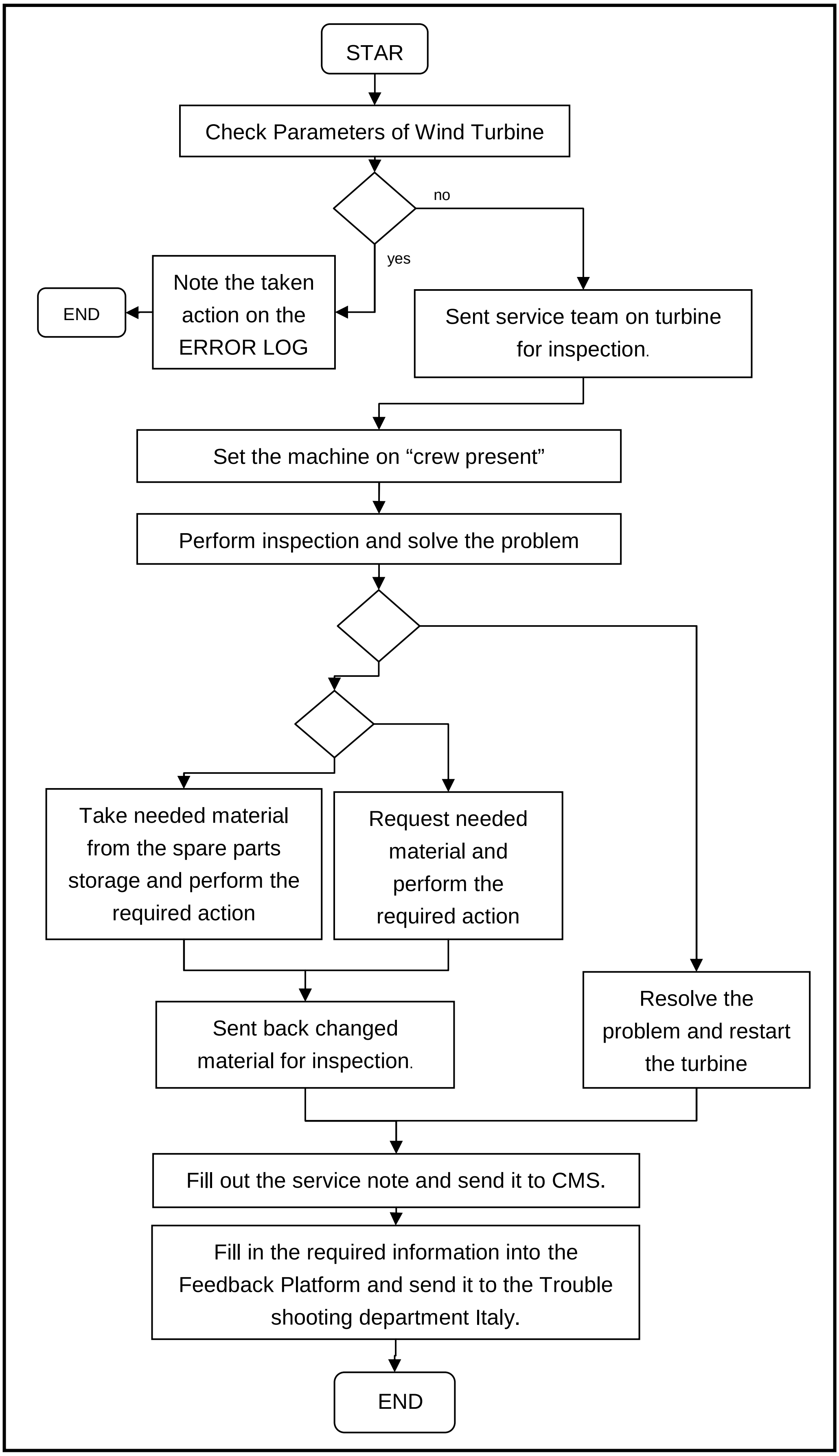


Figure 3-12: improved Feedback Process

In the improved Feedback Process as shown in Figure 3-12: improved Feedback Proces, the CMS has the responsibility and the duty to monitor all the Indian machines and perform all the error resets on them. The service team at the site will only be involved if the errors can't be resolved by resetting the machine and an additional inspection on the operating machine is required.

This will ensure a full overview of the Central Monitoring Station over the ongoing inspections and service actions taken by the service team. Also the important information of actual problems are recorded faster and do not require additional checking by the CMS after works are already started. Furthermore, as the CMS is working together with the trouble shooting department from Italy to find the solution and cause for different problems, the CMS can give an additional input to the service team right from the beginning of the service task having experienced data from previous actions.

The Feedback Process starts with the detection of an error on an Indian machine. The CMS checks the parameters of the relative machine and tries to reset the machine in order to restart its operation. If the reset was successful, the error is documented I the Error Log and the process ends. If it is not possible to restart the machine and the error keeps coming and stopping the machine, the CMS has to inform the responsible service team and send them to the respective machine. The service team, once assigned for the inspection on a turbine will be responsible for that machine until the resolving of the problem and the completion of the works. To ensure the maximum safety every service team will have to set the machine to “crew present”-status while working on it. This will also give a first feedback to the CMS that the works on the machine have started. To resolve the problem there are three different possible situations. One, the service team can resolve the problem without the need of additional material, two, additional material is needed and taken from the spare parts storage at the site, three, additional material is needed. This has to be requested from the CMS that is in charge of the spare parts. The parts that are replaced have to be documented and send back to quality for inspection.

Detailed notes and information regarding the problem cause, consequences and problem solving have to be noted on the service note. This has to be handed over not after 10 days from the service inspection to the service team supervisor and to the CMS. This information has then to be introduced into the Feedback platform by the CMS and send to the Trouble shooting department in Italy.

Figure 3-13 shows the simplified process map

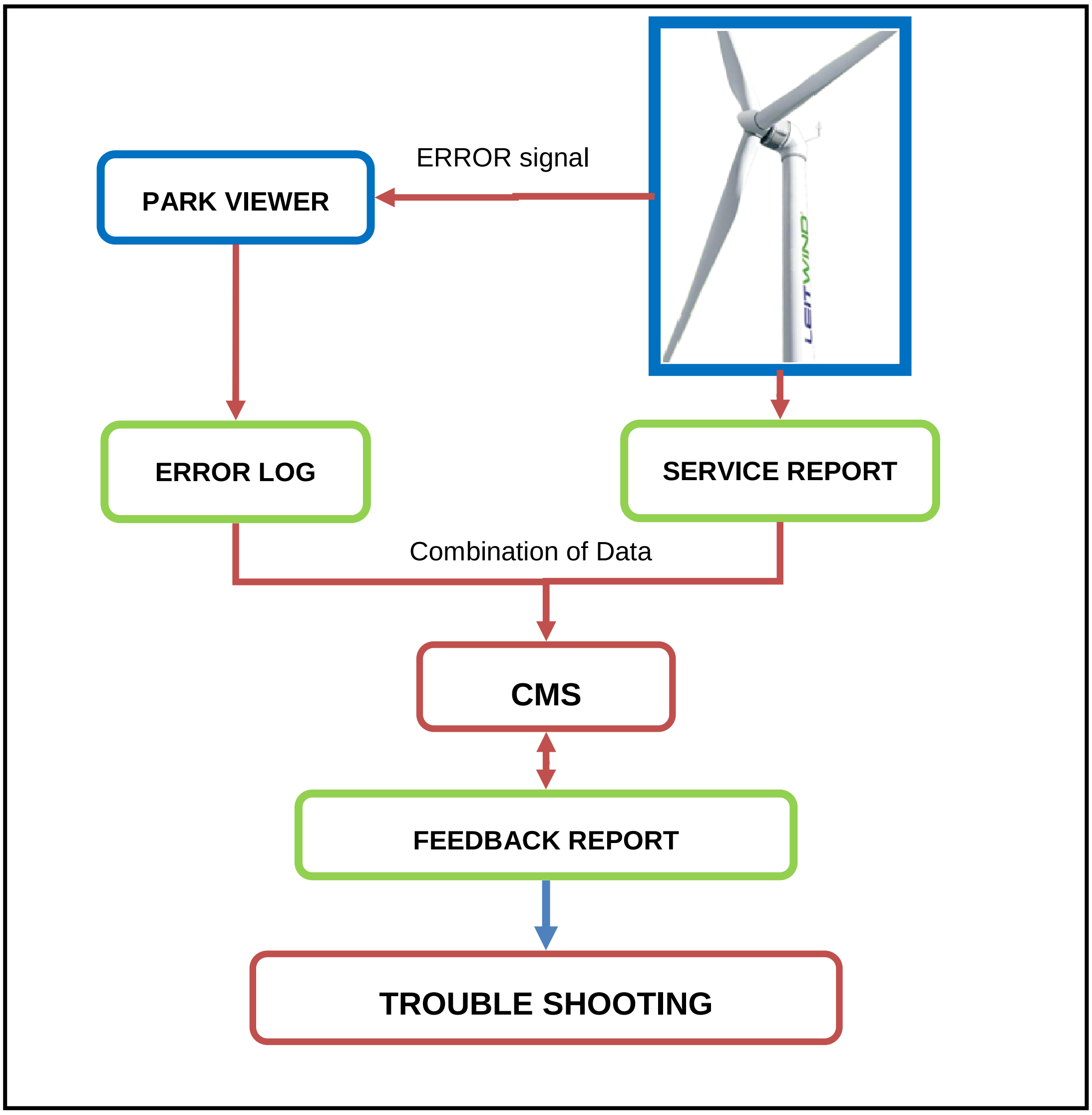


Figure 3-13: Feedback Process Map (own illustration)

During monitoring of the wind turbines and managing the service reports a large amount of data is collected. The selection of needed data for failure analysis is crucial to avoid that useless data distract from the actual problem. The platform should contain data from the error log and from the service report, in order to show all occurred problems and the taken actions on the different machines.

The Feedback platform consists out of four sections, error log, service notes, machine overview and machine log.

Error Log: the error log is the diary of all occurring errors on the monitored machines. It contains data on the type of error, the affected machine, time and duration of stoppage, action taken and person who performed the action.

Service Note: the service note is a summary of the service activities performed on the machines with information on the taken actions, cause for the intervention, duration and changed components,

Machine Overview: in the section Machine Overview, information on errors occurred on the different machines is given. Problematic machines can be seen fast end very effectively on this view. From here the user can choose one particular machine, from which he wants to see more detailed information, and reach the machine specific section. The information that is displayed in this section is: location, date of origin, actual status, error last month, error actual month, total errors and availability.

Machine specific section: here the more detailed information can be seen for every single machine. All occurred errors and all taken actions are displayed. The important part is the connection between errors and taken actions. Frequency of often occurring problems is shown and their occurrence over a specified time period.

3.3.4 Realization of the improvement

With the realization of these improvements less people will be needed performing the same job: CMS takes over the monitoring of all the machines and with that has the total overview over all the service activities. Because of the fact that the people already perform this task on international machines they can also do it on Indian machines. There is no need for an extra person to monitor the machines at every site.

The efficiency of the troubleshooting will be enhanced. Failure analysis can become more accurate and much faster, having always up to date data on occurring problems on operating turbines all over the world.

The better overview on the ongoing works on every machine will also help to request the needed service reports and information at the end of the taken action. Also the different service teams can be supplied with information on the occurred problems and feed them with suggestions how to solve the problem. This can shorten working times and increase the availability.

For the right implementation the CMS will have to get the total control over the running machines, and only them be responsible for the monitoring and the performing of the restarts. The service teams are ready to operate and are under the control of the CMS. The CMS will coordinate the works done by the service teams. After the taken actions the service report has to be created not later than 10 days after the operation. With this information the feedback report can be created by combining the error log and the information from the service reports. The Feedback reports can also be used to perform trouble shooting already by the CMS in India. By these measurements the collaboration with the Italian Trouble shooting department will be improved and should help improve the performance and availability of the machines faster.

4 Conclusion and Outlook

The focus of this thesis was on the Quality Management of LSML in India. The main ongoing processes had to be observed and described. Furthermore the communication processes between India and Italy had to be analyzed and improved in order to close the communication loop. For this the connection between the continuous improvement processes and the feedback process that connects the data for failure analysis was analyzed and improved.

In a modern quality management system continuous improvements are vital for the survival of a fast growing company. Parallel development and production of high technology products require good functioning communication channels in order to bring later upcoming production problems to the first steps of engineering. Globalization also stretched the distances between different departments. It is nowadays possible to combine different benefits of various countries over the world in order to enhance the efficiency of the company. Also LEITWIND benefits from this by developing their Wind turbines in Italy and producing them in India. This on the other hand demands for standardized and effective communication processes.

This led to the task to improve the communication channel between India and Italy and connect the two continuous improvement processes. A good continuous improvement process is characterized by simple process steps and fast feedback. This will keep the motivation of the employees and the quality of the suggestions high.

The main focus during the completion of the thesis laid in the analysis of the actual communication and the finding of solutions to problems that affect the actual process. At the Indian manufacturing site the different procedures where discussed with the responsible people and the process was improved step by step with the involved employees.

The outcome of the CI-Process convinced the management, so that it was implemented right away. For the standardization and documentation of the process a process manual for the involved people was created with all the regarding documents like CIP-Platform, proposal form and CIP-Person email address to exchange the information.

The driving force for the set up of the feedback process was the fact that the trouble shooting of occurring problems on running machines is performed in

Italy, the majority of wind turbines however are installed in India. Although data on errors and status of the worldwide machines are already available in the system, the more detailed information on taken actions has to be requested one by one by the CMS in India. Already a simple report on replaced components on the different machines in India was sent to Italy, but this had to be improved to enhance the benefit of the data.

In collaboration with the CMS in India and the responsible for the service teams the process regarding the organization of the service actions and the documentation of the taken actions was analyzed. The feedback process contains some improvements to the process that still need to be implemented. Whereas the feedback platform, that connects the information on errors and taken actions by the service team is already in use by the CMS.

The improvements made to both the Continuous Improvement Process as also to the Feedback Process are little steps that should help facilitate and enhance companywide communication. Both processes will and have to further evolve during the next years. In addition the implementation of new software, that will connect both companies will standardize and bring both processes to the next level without having to make big changes in the process structure.

List of Figures

List of Tables

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List of Abbreviations

C

CIP	Continuous Improvement Process
CIP-P	Continuous Improvement Process-Person
CMS	Central Monitoring Station

D

DDR LSML	Destination Department Responsible LSML
DDR LW	Destination Department Responsible LEITWIND

I

IP	Improvement Proposal

J

JIS	Japan Industrial Standard
JUSE	Union of Japanese Scientists and Engineers

K

KVP-P	Kontinuierlicher Verbesserungs Prozess-Person

L

LSML	Leitner Shriram Manufacturing Limited

M

MR	Modification Requests

N

NC	NonConformities

Q

QA	Quality Assurance
QC	Quality Control
QI	Quality Improvement
QM	Quality Management
QMS	Quality Management System
QP	Quality Policy

QPL Quality Planning

T

TQC Total Quality Control

TQM Total Quality Management

Appendix A

Main Processes of LSML

Leitner Shriram Manufacturing. Ltd.

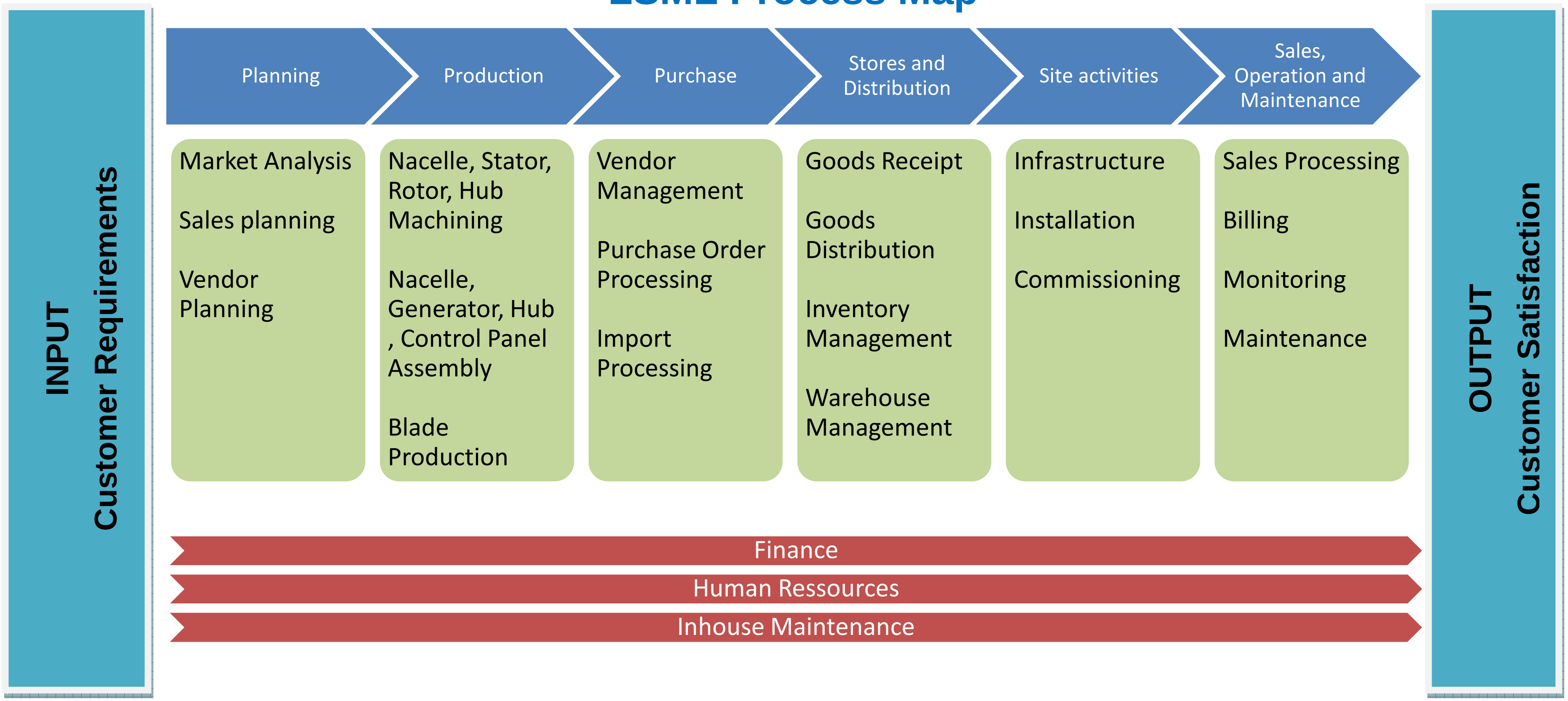
TOTAL QUALITY IMPLEMENTATION PLAN : 2010-2011

S.No	MONTHS / *Process Design / Activities*	1	2	3	4	5	6	7	8	9	10	11	12	13
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
		2010										2011		
1	Daily Management workshop for senior management													
2	TQM awareness program for vendors / sub contractors													
3	Daily Management - Facilitators													
4	Daily management - officers/ Staff													
5	Daily Management Review													
6	Skills Inventory Manual													
7	Work instructions Manual													
8	Model machine manual for TPM													
9	Internal customer Interface													
10	TQM Drivers' development process													
11	All Machines manual for TPM													
12	TQM awareness program for officers - 100% coverage													
13	TQM awareness for technicians													
14	Process Manual for Technicians Trainers													
15	Selection of Technician trainers													
16	Technician Trainers Development process													
17	GPO & QC tools trainig for technicians by Technician													
18	CWQC manual													
19	Facilitators development process- third phase													
20	Vendors Development Phase Two													
21	Learning Cross Functional Projects[CFP's]													
22	Jishu Hozen													
23	5S													

Patented, Under the guidance of Mr.T.R.Natarajan

Total Quality Implementation Plan for the years 2010 and 2011.

LSML Process Map



Appendix A

Process	***ISO Clause***
Design, Development, Issue & Change control	7.3
Marketing	7.2
Customer Complain	7.2.3
Customer Feedback	7.2.3
Purchasing	7.4.1
Material Receipt & Issues	7.5.5
Production	7.5.1
Identification & Traceability	7.5.3
Control Panel – Production	7.5.1
Receiving Inspection & Testing of Materials	7.4.3
In process Monitoring & Testing	8.2.3
Calibration	7.6
Final Testing of Turbine Assembly	8.2.4
Control of Non Conforming Products	8.3
Competence, Awareness and Training	6.2.2
Preventive Maintenance	6.3
Planning	7.5.1
Site Selection	8.2.4
No Objection Certificate	8.2.4
Site Project Planning & Site Activities	7.5.1
Foundation	8.2.4
Control Room	8.2.4
Wind Turbine - Assembly & Installation	8.2.4
Electrical Installation	8.2.4
Testing & Commissioning	8.2.4
Material receipt & Issues	7.5.5
Wind Turbine Operation & Maintenance at Site	8.2.4

Listing of all documented processes with their number according to the ISO standard.

Appendix B

Continuous Improvement Process

PROCESS DELINEATION	
Process name. Continuous Improvement Process	
Purpose: The information flow of continuous improvements between the LSML and LEITWIND should be structured and documented.	
Customers of the process: • Continuous Improvement Process LEITWIND	**Expectations of the customer:** • New experiences during manufacturing • New ideas and suggestions for improvements regarding the product
Output: Implementation steps of improvement that should improve the product or process.	
Input: Thought of improvement. Idea and Suggestion by employee.	
First process step: Submit proposal.	
Last process step: Check right implementation of the improvement and evaluate it.	
Interface at input: All the departments at the Factory in Gummidipoondi.	
Interface at output: Head of regarding department responsible to implement the improvement.	
Necessary resources: • **Human:** CIP-Person, KVP-Person. • **Information, documents and know-how:** Modification request, Improvement Proposal form, Non conformity form. • **Work environment, equipment, and infrastructure:** CIP-Platform, shared folder on server, communication per email.	
Success factors: Involvement of whole staff, quick and accurate feedback to given suggestion, Closed loop system. Fast implementation of good suggestions.	

process – input	**Flow chart**	**aid & annotations**	**responsibility** (1)...realization (2)...assistance (3)...information	**process – output/ Documentation** (1)...output/document (2)...interface
Thought of improvement, in the field of: • Quality • Time reduction • Cost reduction • Motivation • Safety • Design	START ↓ Problem, modification request is sent to responsible person	When facing a problem where a modification is needed, the supervisor sends a modification request to the technical department Here the machine shop, quality department and the purchase department are already using the **FORM** form. Pictures are also added to the form. Problems found at the erection site are sent by emails or discussed via telephone. The assembly department transmits this information only orally to the technical department	(1) LSTD (1) LSPU (1) LSMS (1) LSQD	(1) mail (1) **FORM** (2) LSTD (2) LSPU (2) LSMS (2) LSQD
	Classification of the problem	The technical department decides whether it is a major or minor problem. Problems regarding Nacelle, hub, generator, blades, Tower shell and structure are always classified as major problem and are always forwarded to LEITWIND. This decision is taken by KE and DA.	(1) LSTD (3) KE (3) DA	
	◇ → Internal modification	Problems declared as “minor” are solved internally. Drawing revisions and changes are made, no extra documentation is done.	(1) LSTD	
	Problem-, modification request is forwarded to LEITWIND	All problems classified as “major” are reported to LEITWIND. Technical department forwards the form **FORM** already filled out by the machine shop, quality department and the purchase department to LEITWIND.	(1) LSTD (1) LWTD	**(1) FORM**
	◇ → END	LEITWIND technical dept: checks feasibility of request.	(1) LWTD	
	Modification is performed and LSML is informed ↓ END	LEITWIND answers to the modification request with comments and if required with the needed drawings. KE and DA have access to LOTUS NOTES. Other depts. have to be informed by mail.	(1) LWTD (1) KE (1) DA (1) CH	(1) mail

Abbreviations: IS... installation site, LSTD...LSML Technical department, LSPU…Purchase department, LSMS… Machine shop, LSQD…Quality department, KE...Head Technical Department (TD), DA...TD, CH...TD, AN...TD, KÄ...TD, FA...TD, LWTD...LEITWIND Technical Department

Problem Solution Analysis

Problem: No clear defined communication channel, everybody communicates with everybody via email.

Solution: A single communication channel should be established. His function will be to survey the exchange of data and information and to check the actual status of each request.

P: No documentation on suggestions, problems, modification requests, ratifications or updates

S: Given that there is only one communication channel, the documentation can be made more easily. Emails are channeled through a single email address.

P: No feedback on estimated execution time of modification, this leads to delays in planning of the LSML technical department

S: Execution times have to be inserted in the CIP-Platform of the system so that it is more clear to the

P: No feedback if LEITWIND is working on actual problem. This leads to various requests via email.

S: Status can be monitored on the CIP-Platform, no need for unnecessary email exchange.

P: No standardized way of reporting problem, media used: email, phone, pictures, text, FORM.

S: FORM will be the standard reporting sheet, important info is inserted on CIP-Platform and sheet is saved in a shared folder.

P: The heads of the technical departments do not have time to manage extra excel files. They are in charge of the technical problem solving and should be disburdened of extra organizational problems.

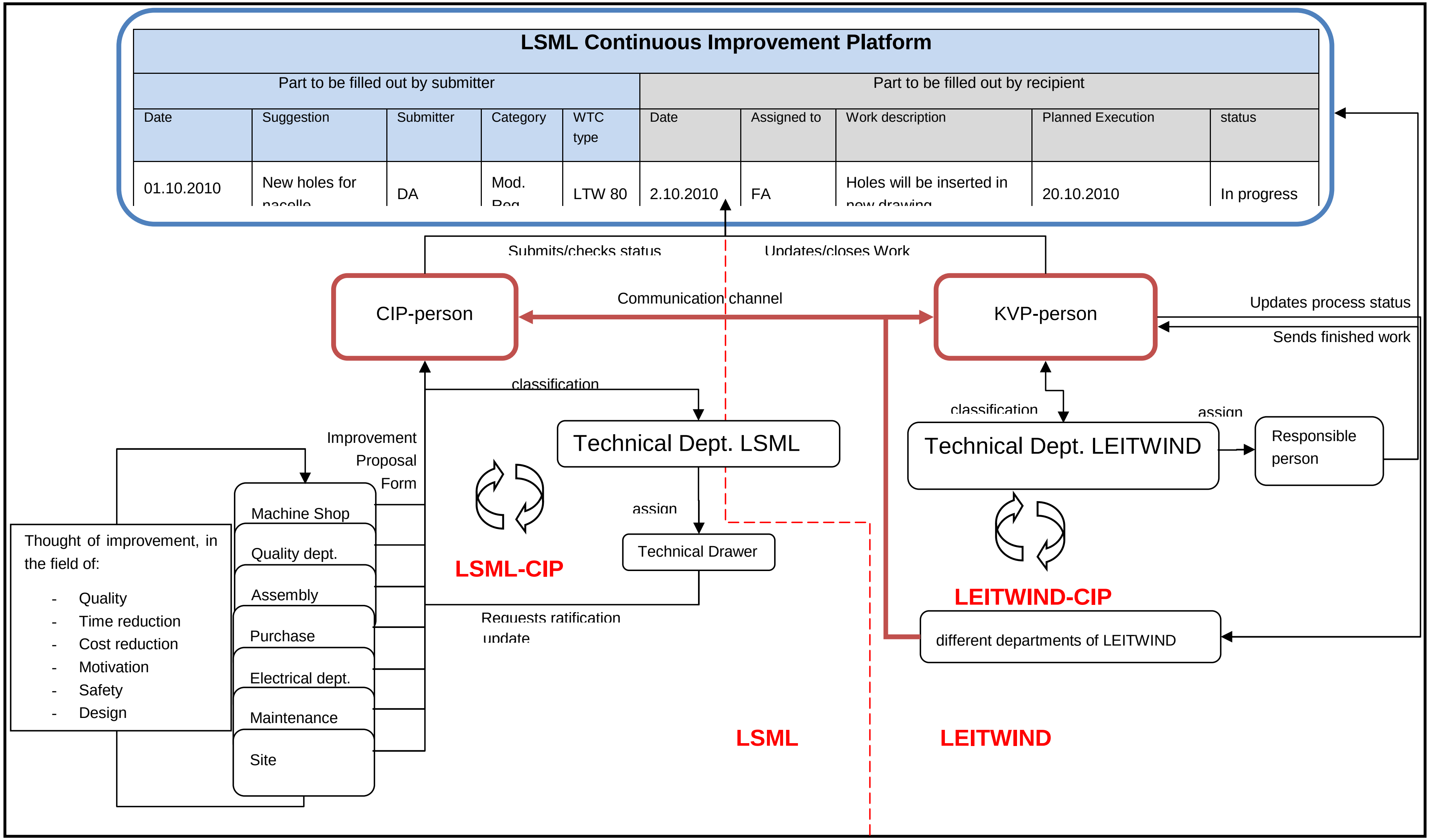
S: CIP-Person takes over organizational problem and prepares the problems in such a way that responsible only has to delegate the work.

Appendix B

process – input	**Flow chart**	**aid** & annotations	**responsibility** (1)...realization (2)...assistance (3)...information	**process – output/ Documentation** (1)...output/document (2)...interface
• Improvement Proposal • Modification request • Nonconformity • Drawing ratification • Drawing, specification update	START	Any kind of IP/NC/MR has to be submitted to the Continuous Improvement Process.		
	Fill out regarding document and hand it over to the CIP-Person	Fill out **improvement proposal form**, non conformity document **QA/F02/B**, modification request **FORM** or update request and hand it over to the CIP-Person	(1)…DEPT (3)…CIP-P	(1)…Improvement Proposal Form (1)…Non conformity document (1)…FORM
	Collect incoming IP/NC/MR.	Periodically collect the IP/NC/MR from the different departments	(1)…CIP-P	
	decline → END	Hand over to **Destination Department Responsible** (DDR LSML) for Feasibility check. Can IP/NC/MR be passed on? If not, explain why and end the process.	(1)…CIP-P (1)…DDR LSML	
	Internal CIP.	Can the IP/NC/MR be solved internally? Start with the internal Continuous Improvement Process.	(1)…DDR LSML (1)…CIP-P	
	Submit IP/NC/MR to CIP-Platform and forward it to KVP-P	The CIP-Person transfers the information from the IP/NC/MR into the CIP-Platform and saves the documents on shared folder. Notification has to be sent to KVP-Person.	(1) CIP-P (3)…KVP-P	(1)…Updated CIP-Platform (1) …FORM
	Check updated Platform and assign work	New IP/NC/MR. appears on CIP-Platform. KVP-Person assigns work to DDR LW. Each department Head will then assign the work to the responsible person.	(1)…KVP-P (1)…DDR LW (3)…Resp	
CIP-Platform Drawings, regulations, specification	Perform work task and update process status on CIP-Platform	Keep the CIP-Platform updated to avoid unnecessary email traffic.	(1)…LWTD (1)…Resp	(1)…Updated CIP-Platform
	Sent result of the assigned work to CIP-Person and to submitter	The work has to return to the CIP-Person and to the submitter. Only by this, clear documentation of the process is ensured and a clear communication channel established.	(1)…Resp (3)…CIP-P (3)…Submitter	(1) …Required Document
	Update the CIP-Platform and mark the work as completed.	After sending the finished work back to LSML close down the request by updating the CIP-Platform.	(1)…CIP-P (3)…DDR LSML	(1)…Updated CIP-Platform
	Control the implementation of the improvement and comment its effectiveness.	Quarterly perform an evaluation of the implemented improvements and modifications and document its effectiveness.	(1)…CIP-P (3)…DDR LSML	(1)…Updated CIP-Platform
	END			

Abbreviations: DEPT… different Departments, DDR LSML…Destination Department Responsible LSML, DDR LW…Destination Department Responsible LEITWIND, CIP-P… CIP-Person (India), KVP-P … KVP-Person (Italy), Resp … responsible person

Process Map: Continuous Improvement

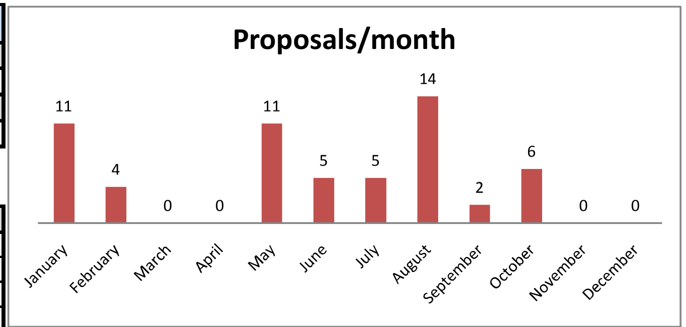


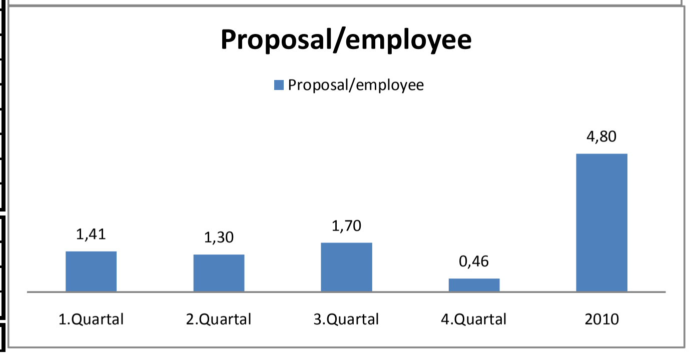
CIP-Platform										
Part to be filled out by submitter						Part to be filled out by recipient				
Problem no.	Date	Suggestion	Submitter	Category	WTC type	Response Date	Assigned to	Planned Execution	Work description	status
2.2010	03.07.2010	New flange for nacelle……	Peter	Mod. Req.	LTW 80	14.10.2010	AN	13.07.2010	Holes will be inserted in new drawing	in progress
6.2010	02.08.2010	New bearing for nacelle……	KE	Suggestion	LTW77					
13.2010	17.09.2010	New flange for nacelle……	DA	Ratification	LTW77					
10.2010	19.09.2010	New flange for nacelle……	Peter	Movex Update	LTW77	14.10.2010	FA	23.09.2010	Holes will be inserted in new drawing	in progress
24.2010	12.10.2010	New holes for nacelle……	DA	Mod. Req.	LTW77	14.10.2010	GO		Holes will be inserted in new drawing	in progress
25.2010	17.10.2010	New bearing for nacelle……	DA	Mod. Req.	LTW 80					
26.2010	20.10.2010	New flange for nacelle……	KE	Mod. Req.	LTW 80	27.10.2010	FA	02.10.2010	Flange will be inserted in new drawing	finished
26.2010	20.10.2010	New flange for nacelle……	DA	Mod. Req.	LTW 80					

CIP-Cockpit:

12.11.2010 15:54	Control Cockpit		
	This Month		Total
Suggestions	0		10
	% under 14 days	Current work in progress	Current open Works
Response Time	50,00%	115	5

2010	Proposals	Average Employees	Proposal/Employee
January	11	12,00	0,92
February	4	11,00	0,36
March	0	9,00	0,00
April	0	12,00	0,00
May	11	12,00	0,92
June	5	13,00	0,38
July	5	13,00	0,38
August	14	12,00	1,17
September	2	12,00	0,17
October	6	14,00	0,43
November	0	13,00	0,00
December	0	12,00	0,00
1.Quartal	15,00	10,67	1,41
2.Quartal	16,00	12,33	1,30
3.Quartal	21,00	12,33	1,70
4.Quartal	6,00	13,00	0,46
2010	58,00	12,08	4,80

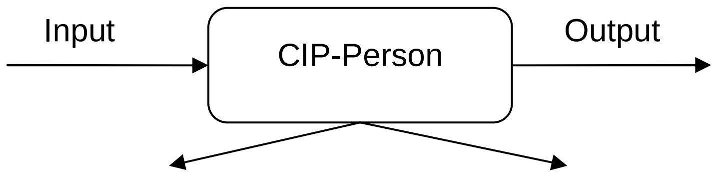




Appendix B

Process member Task cards:

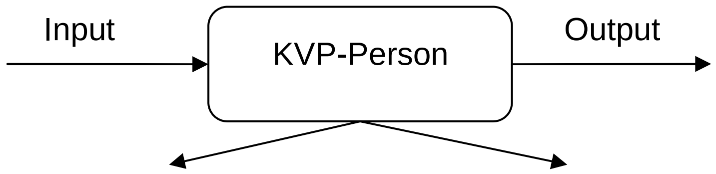
CIP-P… CIP-Person (India):

<table>
<tr><td>Process member:</td><td colspan="2">CIP-Person (India)</td></tr>
<tr><td>Interfaces</td><td colspan="2">

KVP-P DDR DEPT</td></tr>
<tr><td>Interfaces:</td><td colspan="2">➢ KVP-Person
➢ Destination Department Responsible
➢ Different Departments</td></tr>
<tr><td>Input:</td><td>Process tasks:</td><td>Output:</td></tr>
<tr><td>• Improvement Proposal
• Modification request
• Nonconformity
• Drawing ratification
• Drawing, specification update</td><td>In charge of CIP-email address and manages the LSML CIP-Platform.
The CIP-Person has to manage the communication and knowledge flow between LSML and LEITWIND.
All the IP/NC/MR have to be submitted to the CIP Process Platform.
Documentation of the Process has to be ensured.
The communication has to be as clear as possible, if person is not available due to illness, holiday or position change; it should be possible to transfer this work without any problems.
Quarterly perform an evaluation of the implemented improvements and modification and document its effectiveness.</td><td>• Updated CIP-Platform with requests and regarding documents</td></tr>
</table>

Appendix B

KVP-P … KVP-Person (Italy):

<table>
<tr><td>Process member:</td><td colspan="2">KVP-Person (Italy)</td></tr>
<tr><td colspan="3">
Interfaces - CIP-P Resp LW CIP DDR LW</td></tr>
<tr><td>Interfaces:</td><td colspan="2">➢ Responsible person
➢ CIP-Person
➢ LEITWIND Continuous Improvement Process
➢ Destination Department Responsible LEITWIND</td></tr>
<tr><td>Input:</td><td>Process tasks:</td><td>Output:</td></tr>
<tr><td>• Updated CIP-Platform with requests and regarding documents</td><td>In charge of the KVP-email address and manages the CIP-Platform.

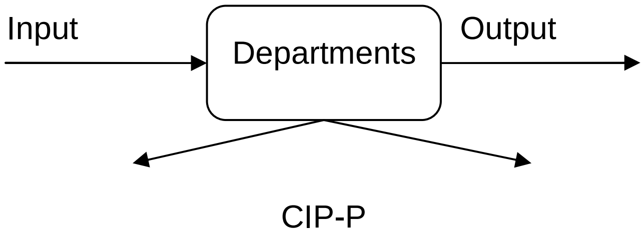
The KVP-person has to forward new incoming assignments from LSML to the DDR LW.

Improvement Proposals are introduced in the LEITWIND Continuous Improvement Process.

Documentation of the Process has to be ensured.

The communication has to be as clear as possible, if person is not available due to illness, holiday or position change; it should be possible to transfer this work without any problems.</td><td>• Updated CI-Platform
• Work assignments</td></tr>
</table>

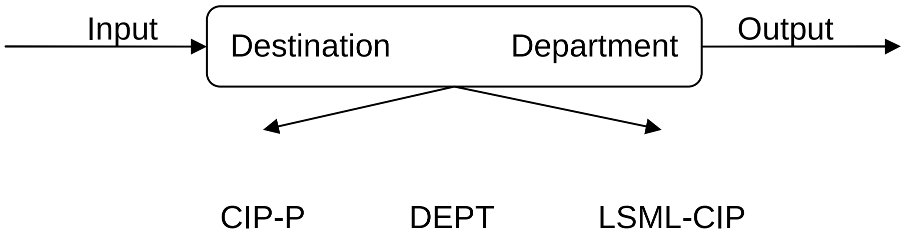
DEPT… different Departments:

<table>
<tr><th>Process member:</th><td colspan="2">All the departments of LSML</td></tr>
<tr><td colspan="3">Interfaces

</td></tr>
<tr><th>Interfaces:</th><td colspan="2">➢ CIP-Person</td></tr>
<tr><th>Input:</th><th>Process tasks:</th><th>Output:</th></tr>
<tr><td>• Problem
• Idea</td><td>After finding a problem during manufacturing or having an idea regarding the product, that could lead to an improvement in the field of: Quality, Time reduction, Cost reduction, Motivation, Safety or Design the different departments have to fill out either the Improvement Proposal Form for an idea or the FORM for a modification request.

If a Non conformity is found a NC has to be filed and handed over to the Head of Department

The documents have to be handed over to the CIP-Person.</td><td>• Improvement Proposal
• Modification request
• Nonconformity
• Drawing ratification
• Drawing, specification update</td></tr>
</table>

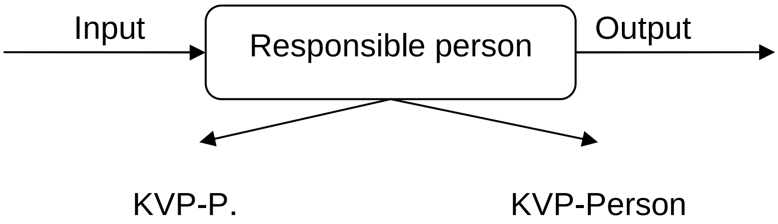
DDR…Destination Department Responsible:

<table>
<tr><td>Process member:</td><td colspan="2">Destination Department Responsible</td></tr>
<tr><td colspan="3">Interfaces
-

</td></tr>
<tr><td>Interfaces:</td><td colspan="2">➢ CIP-Person
➢ Departments
➢ LSML Continuous Improvement Process</td></tr>
<tr><td>Input:</td><td>Process tasks:</td><td>Output:</td></tr>
<tr><td>• Improvement Proposal
• Modification request
• Nonconformity</td><td>Feasibility check of the submitted FORM and Improvement Proposals.

Classification of the IP/NC/MR request has to be done, to see if it has to be forwarded to LEITWIND trough the CIP-Person or if it can be handled internally.

If handled internally, implement the improvement or make modification according to LSML procedure.</td><td>• Approval
• Assignment
• Implementation</td></tr>
</table>

Resp…Responsible person:

<table>
<tr><td>Process member:</td><td colspan="2">Responsible person</td></tr>
<tr><td colspan="3">Interfaces

</td></tr>
<tr><td>Interfaces:</td><td colspan="2">➢ Technical department
➢ KVP-Person</td></tr>
<tr><td>Input:</td><td>Process tasks:</td><td>Output:</td></tr>
<tr><td>• Work assignments</td><td>He has to perform the assignment given by the KVP-Person.

The finished work has to be sent back to the submitter and to the CIP-person.</td><td>• Finished work
• Status update</td></tr>
</table>

Continuous Improvement Process-Implementation at LEITWIND and LSML

1st Phase of the implementation will take for 2 months in order that the involved people get familiar with the new process. The KVP-Process at LEITWIND also has to adopt some changes during this period.

Steps for the 1st implementation-phase of the CIP at LSML:

1. Select a CIP-Person out of the technical department, who will be the responsible of the process
2. Set up the email account
3. The mechanical department will be the first department where the CIP is implemented
4. Introduce the new Improvement Proposal Form in the department
5. Start with the first request through the CIP-Person
6. Introduce the first proposals and requests in to the CIP-Platform
7. After the testing phase start with 2nd implementation phase

Steps for the 1st implementation-phase of the CIP at LEITWIND:

1. As there is not yet a KVP-Person responsible for the process, AN can be the Person who takes care of the incoming requests from the CIP-Person in the 1st phase, as there will only be requests from the mechanical department from LSML
2. Set up the KVP-P email account and assign it to the responsible person
3. The first request through the CIP-Person will come to KVP-P.
4. Forward them to the responsible person, who has to take care of the problem
5. One copy of the finished work has to be sent back to CIP-P in order to keep track of the finished works
6. Weekly the Platform will be send to the KVP-Person for a short status update of the requests.
7. After the testing phase start with 2nd implementation phase

2nd Phase of the CIP will shortly introduce the different departments of both LEITWIND and LSML until the whole company is connected.

Steps for the 2nd implementation-phase of the CIP at LSML:

1. A CIP-Board has to be set up, to evaluate future improvement proposals coming from the different departments.
2. Set up the shared folder on the shared server as soon it is available
3. The CIP-Person has to start introducing the CIP to the remaining departments, starting from the electrical department
4. Every 3 months, an evaluation of the implemented proposals has to be done to measure their improvement and check their right implementation.

Appendix C

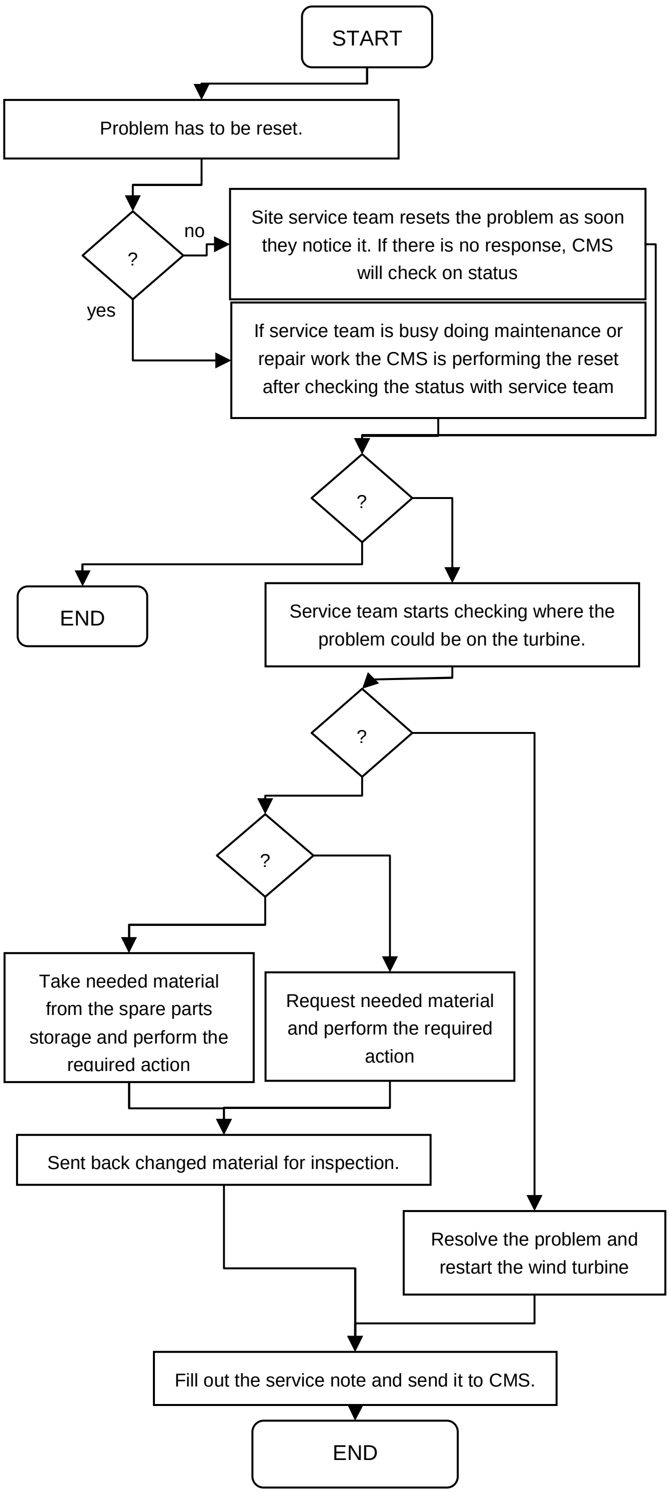
Feedback Process

Process name Feedback process
Purpose: Purpose of the process is to ensure the transfer of information from site activities in India to the trouble shooting department in Italy. This gained data will be needed for failure analysis.

Customers of the process: - Trouble shooting department Italy	**Expectations of the customer:** - Clear, up to date data.

Output: Weekly updated Platform containing useful data on risen errors and descriptions on taken actions and services.
Input: Error description and detailed information regarding the taken action to resolve the error.
First process step: Report error to service team.
Last process step: Update the platform with the latest information from the service teams.
Interface at input: Maintenance and operation team.
Interface at output: Trouble shooting department in Italy.
Necessary resources: • **Human:** one person taking care of the process at the CMS. • **Information, documents and know-how:** service report, error information from park viewer and firm monitoring SW. Know-how of the different processes going on in the CMS. • **Work environment, equipment, and infrastructure:** Work can be performed with the computer and communication through email.
Success factors: Fast access to detailed information on occurred breakdowns over the world by the trouble shooting department

Appendix C

process – input	**Flow chart**	**aid & annotations**	**responsibility** (1)...realization (2)...assistance (3)...information	**Process output/ Documentation** (1)...output/document (2)...interface
ERROR on WTG		Resetting of the machine has to be performed according to the **Control System Manual**. Follow document **LSML/WIF16/A**.	(1)…CMS (1)…Service	(1)…ERROR log
		It is not clear whose responsibility is to reset the machine after the ERROR occurs.CMS and site people monitor the machine but no one is fully responsible for it.		
		If the problem can be resolved without intervention of service team the process ends here.		
		CMS is informed or CMS will check status by itself. Also here the information flow is not clear enough. Often the CMS does not get the information from the service teams.	(1)… Service (3)…CMS	
		Is there some damaged material that has to be changed?		
		Is the material available in the spare parts storage at the site?		
		Needed material is either taken from spare parts storage at site or requested from CMS. The process how the spare parts storage at the site has to be refilled is also not yet defined.	(1)… Service (2)…CMS	
		Machine number, SW error and defect in component are noted on a white tag attached to the broken component.		(1)…White tag on component
		The service report with all the specific information on the taken action should be sent to the CMS, but is not been done properly lately so that a lot of data is missing.	(1)… Service (3)…CMS	(1)…service note QM/F03/A

Abbreviations: CMS…Central Monitoring Station, Service…Service Team

Problem/Solution analysis:

Problem: One of the biggest problems nowadays is that the service reports are not sent to the CMS in time. As now (2.12.2010) the service notes are still missing from the 10th of August.

Solution: The focus is not put on the information flow from site to CMS. A lot of reports are done by the CMS containing a huge amount of data. Data on daily generation, availability and upcoming errors. But still the most important data, containing the information on how the problems were resolved and what was the cause of the problems, is missing. This information has to reach the failure analysis team and so the design team to improve the product in future.

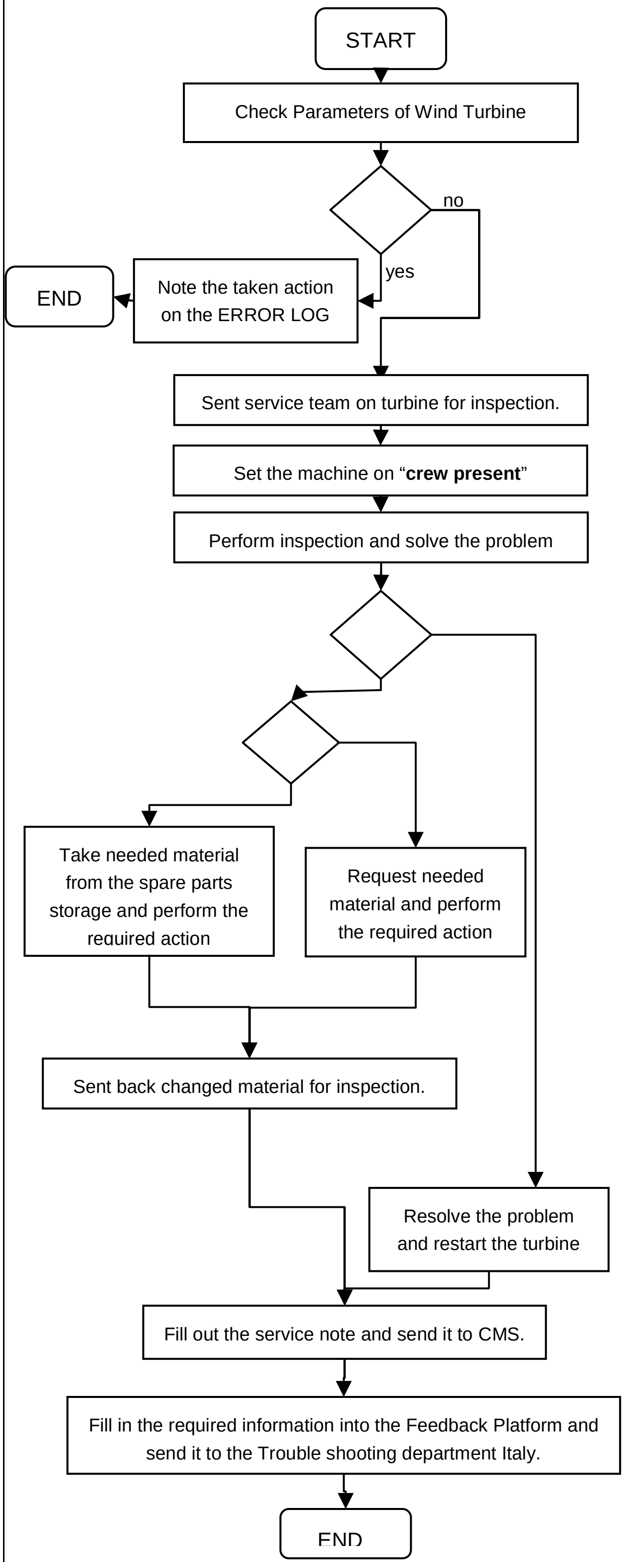
P: Some tasks are not clearly defined by whom they should be performed. Therefore time is spent by both the CMS and the service teams to perform the same action, for example the monitoring of the operating turbines: in the CMS as at the site a team of people are working 24/7. Both are monitoring the machines and trying to solve risen problems.

S: Decide which team is responsible of monitoring and reset the machines. The CMS should perform it as they already do it on the international machines. If the ERROR cannot be solved through pc the service team has to be informed and sent to the specific machine for inspection. At the moment where the service team is on the turbine, it should be blocked and the service team is in charge of it until the problem is solved. Turbine is restarted again and the service report has to be sent to the CMS for documentation and failure analysis.

P: As the CMS has no overview on ongoing works on the different machines, they also do not know if the service team is working on certain machines or not. This is also because it is not yet possible for every service team member to block the machine correctly but only by triggering the emergency stop button. This leads to different ERRORS where the CMS does not know if they are caused by the machine or by the service people performing some work.

S: By reorganizing the procedure steps between CMS and the service teams the CMS will always have the overview on ongoing works on every machine. This would make the most sense, as they are responsible for the monitoring of the machines, the organization of the spare parts on the site and for the failure analysis.

Appendix C



process – input	**Flow chart**	**aid & annotations**	**responsibility** (1)...realization (2)...assistance (3)...information	**process – output/ Documentation** (1)...output/document (2)...interface
ERROR on WTG		Reset the machine according to the **Control System Manual**. Follow document **LSML/WIF16/A**.	(1)…CMS	
		Are the parameters OK? Can the problem be resolved by resetting the machine?		
		If the problem can be resolved without intervention of service team the process ends here.	(1)…CMS	(1)…ERROR log
		Can the problem not be solved, a service team has to be informed and assigned to inspection. Suggestion to problem solving can already be given. Machine has to be set to **"crew present"** for safety reasons.	(1)…CMS	
		According to the ERROR the cause has to be found and resolved.	(1)… Service (2)…CMS	
		Are there any components that have to be changed?		
		Is the needed material available at the site storage?		
		Exchange the broken components with new ones and document it on the service note. If material is not available, request it from the CMS. In the meantime dismount component. Make pictures and find cause for the damage.	(1)… Service (2),(3)…CMS	(1)… Material Request form
		The damaged material has to be sent back for warranty inspection. Note the machine number, SW error and defect in the component on a white tag attached to the broken component.	(1)… Service (3)…CMS	
		Find the cause of the problem, resolve it and reset the ERROR in order to restart the turbine.	(1)… Service	
		The service report with all the specific information on the taken action has to be sent to the CMS **not after 10 days** from finished service.	(1)… Service (3)…CMS	(1)…service note **QM/F03/A**
		The Feedback Platform has to be always up to date in order to ensure a good information transfer between CMS and the trouble shooting department In Italy.	(1)…CMS	(1)…Feedback Platform